Building Net-Zero Communities
Passive House Design
Model Home Technology Showcase

Providing a Paradigm Shift in
Energy Efficiency, Quality & Affordability

Compliance with IECC 2012
State-of-the-Art Insulated Concrete Forms (ICF) Technology
Radiant Glass Windows, Entry Doors (R-14) & Appliances
Geothermal Heat Pump Systems providing Heating, Cooling & Hot Water
Heat/Energy Recovery Ventilation Systems Integrated with Heat Pumps
Solar (Photovoltaic) Power Systems for Net-Zero Homes
Smart Home Sensors, System Controls and Energy Management
Superior Technology & Construction at Affordable Pricing
Energy Tax Credits & Energy Efficient Mortgages (EEM)

Passive House Technology

- Passive technology refers to a house or building that largely heats and cools itself.
- The house or building actually doesn't consume much energy in the form of oil, gas, electricity, or other conventional means, but uses natural resources including geothermal and solar energy to provide virtually all of the energy needed to be self-sufficient.
- Inefficient crawl spaces and attics are replaced with full basements and/or insulated lofts/2^{nd} stories, providing more home for less cost.

Model Home Objective

- Provide an energy efficient model home for homeowners and businessmen to see and experience the economic advantages of reducing energy loads and increasing quality.
- Utilize superior architecture, engineering, building materials, and construction techniques.
- Function as a product distributor and training program for contractors and subcontractors to incorporate state-of-the-art products and services provided by industry partners for construction of energy efficient homes and commercial buildings.
- Use state-of-the-art geothermal heat pump systems and solar photovoltaics (PV) to cost effectively achieve net-zero homes.

Model Home Marketing

- Once the model home is completed an informative website will be developed and an Internet marketing campaign will be launched for new home construction targeting homeowners, businesses, architects, engineers, and contractors.
- The Passive House Model Home (PHMH) will be open 10 hr./day six days a week and will serve as the home office of the distributor (RM Enterprises, LLC).
- The PHMH will not be sold unless a new model home is built in order to showcase newer more efficient technologies developed by industry partners.

Model Home Concept

- Passive House Homes are popular in communities where demand for energy efficiency is understood and appreciated through the use of Model Homes (http://www.zehnderamerica.com/how-the-system-works/video_list.aspx).
- Seeing is believing and energy efficient homes cannot be produced fast enough for informed homeowners who tour model homes.
- One of the keys to mainstream acceptance is integration of passive house technology with conventional architecture.

State-of-the-Art Construction Management

- The paradigm shift in energy efficiency, quality and affordability of the PHMH begins with state-of-the-art construction management.
- During construction, specialized ICF crews and skilled laborers will be trained in leading edge technology provided by industry partners.
- PHMH construction will be completed in a fraction of the time required for stick-frame construction.

Quad-Lock ICF Bracing Systems

- Man-hr. rates are for complete Quad-Lock wall installation including staging, assembly, bracing, concrete pour, bracing removal, and cleanup.
- Productivity will vary based mainly on crew experience, complexity of project, and bracing system used.
- State-of-the-art bracing systems will be developed to increase production from 30 sf/man hr. to over 40 sf/man hr. for experienced ICF crews.

Energy Efficiency & Savings

- Insulated concrete forms (ICF), geothermal heat pump systems, energy recovery ventilators, state-of-the-art passive windows and doors, energy efficient appliances, LED light bulbs, and energy efficient electronics (LED TVs), will be used to reduce energy loads.
- For grid-connected (Net-Zero) homes that produce solar power, it will be strategically advantageous to use all electric appliances in place of natural gas.

Increasing Energy Efficiency, Quality & Affordability

- Extremely tight, super-insulated concrete homes can be constructed in a fraction of the time that it takes for building stick-frame structures.
- It is estimated that experienced crews can install timber framework (in place of shoring) and pine decking, Quad-Deck ICF, radiant systems, and decorative concrete floors for about $6/sf.
- Geothermal heat pump systems and field loops can be installed around the structure footings during excavation of the basement.

Specialized ICF Crews

- For experienced crews, passive windows and doors, HVAC, electrical and plumbing systems, and exterior insulated cultured stone, can be installed considerably faster for ICF structures than for stick-frame buildings.
- Timber frameworks, ceiling pine/fir decking, softwood flooring, custom pine cabinets , decorative concrete countertops, and finish carpentry can be installed faster with a higher level of quality via specialized ICF crews.

Affordability

- Through a 90% decrease in energy loads, the use of geothermal heat pump and radiant systems (which increases total energy efficiency by up to 600%), capitalizing on the thermal mass of concrete, decreasing labor costs via experienced ICF crews, and using locally available products, unprecedented quality and affordability is provided for construction of energy efficient green homes.

Homeowner Sweat Equity

- Additionally, homeowners can do much of the exterior cultured stone products, drywall, and painting, thus adding value via sweat equity.
- This allows the homeowner to purchase more home, invest in a solar PV power system for achieving a Net-Zero Home, or reduce their mortgage payment.

Energy Tax Credits & EEM

- Federal & state tax credits (30% for geothermal heat pump and solar power systems including radiant heating, cooling and hot water; and energy recovery ventilators); and Energy Efficiency Mortgages (EEM) will provide further economic advantages that, in most cases when combined with reducing labor and material costs, will more than offset the 10-20% increase in typical construction costs for Net-Zero homes.

International Energy Conservation Codes Commission (IECC)

Summary of Changes to IECC 2012
(~30% better than IECC 2006)

Major changes

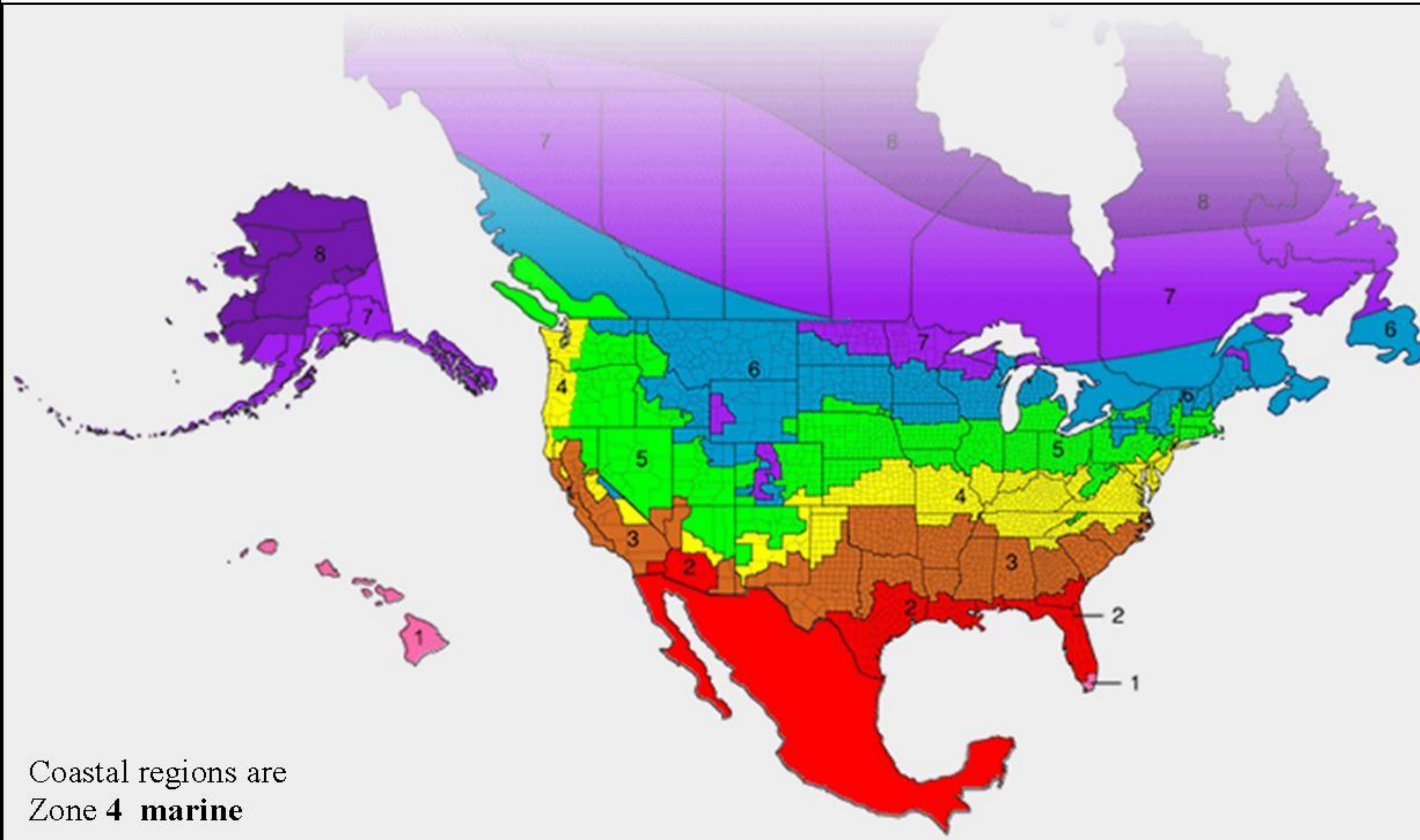
- Consolidated with IRC energy chapter (actually a change to the IRC, not the IECC)
- Mandatory whole-house pressure test
- More stringent duct leakage test
- DHW distribution system requirements

Key non-changes

- Retains prohibition on envelope-equip. trade-offs
- Makes lighting requirements “mandatory”

(http://www.resnet.us/uploads/documents/conference/2012/pdfs/Barcik-Energy_Code-IECC2012_vs_2009IECC.pdf)

ASHRAE/IECC Zone Map



Coastal regions are
Zone **4 marine**

IECC 2012 Insulation Requirements

Cold-climate Buildings

- **Mandatory Foam Sheathing or ICF**
  - The 2012 International Energy Conservation codes will require new homes in cold climates to have exterior foam sheathing, or some similar layer of continuous insulation that interrupts thermal bridging due to using wood studs.
  - An alternative to stick-frame construction is Insulated Concrete Forms (ICF) which meet or exceed all 2012 IECC insulation and tighter envelope requirements.

Summary of IECC 2012

- The 2012 International Energy Conservation Code requires more insulation, a tighter envelope, tighter ducts, better windows, and more efficient lighting than the 2009 code.
- The PHMH project is designed to meet or exceed all of these building requirements through industry partnerships with leading technology providers who will be showcasing their technologies and products at the PHMH.

Immediate Energy Savings

- New 2,400 square foot single family homes in Idaho that meet the 2012 IECC will cost an additional $1,350-1,892 in construction costs per new home.
- Energy cost savings are estimated at between $207 and $267 per year. Stated differently, a homeowner's monthly utility bill savings are at least triple the additional mortgage payment needed to cover the cost of the energy saving features required by the 2012 code.

Net-Zero Homes

- Idaho residents buying new single family homes meeting the 2012 IECC will pocket between $4,139 to $5,038 in net savings over the life of their 30 year mortgage according to an analysis of energy savings and incremental construction costs by the Building Codes Assistance Project and ICF International.
- Similarly, the PHMH project is designed to provide an immediate cash flow from day 1, increasing savings by reducing energy loads by 90% and allowing homeowners to build Net-Zero Homes with minimal investments in grid-connected solar photovoltaic (PV) power systems.

Industry Partners

- Professional Services
- Manufacturers
  - Core manufacturers, e.g., ICF; Heat pumps, radiant heating, cooling, and hot water; windows and doors; concrete providers; timber providers
  - Other manufacturers, e.g., supporting products such as
- Contractors

Professional Services

- James Stewart, Architect, Montana State University, Integrated Design Lab
- Gunnar R. Gladics, Research Scientist – Architectural Energy Specialist, University of Idaho, College of Architecture, Integrated Design Lab – Boise

Core Product Manufacturers

- Quad-Lock Insulating Concrete Forms & Building Systems, LTD
- WaterFurnace 100% Variable Geothermal Heat Pump or Hydro-Temp Earth Coupled Heat Pump integrated with radiant heating, cooling and hot water
- Waterfurnace NSW hydronic heat pump and Viega Climate Mat & Climate Control Technology
- UltimateAir® RecoupAerator® or Zhender ComfoSystems 350 Energy Recovery Ventilators (ERV)
- teckMar Heat Pump, Radiant Heating and Cooling Control Systems via Lundquist Sales, Inc. (Salt Lake City, UT)
- InsulStone - Concrete Cultured Stone and Stucco

Pending Core Product Manufacturers

- Marvin or Alpen Passive Windows, Shades & Glass Doors
- Hammer & Hand Passive Entry Doors
- Concrete companies (to be determined)
- Lodge Logs (Boise, ID)
- Western Timber Products, Inc.
- High Efficiency Appliances (to be determined)
- Solar (photovoltaic) Power Systems (to be determined)

Other Pending Product Manufacturers & Dealers

– Düraamen decorative concrete and resinous flooring systems
– Powerwise Systems, InView Passive House and eMonitoring hardware and software
– Control4 Home Automation Solutions & Home Security
– Sight & Sound by Design - Whole-house Music and Home Theatre

Contractors & Developers

- Don Poulsen, General Contractor
- Scott Flynn - Flynner Homes – Energy Efficient Construction – General Contractor
- Jason Fuller, PE, Idaho Geothermal, HVAC, geothermal heat pumps, ERVs, and Solar PV systems

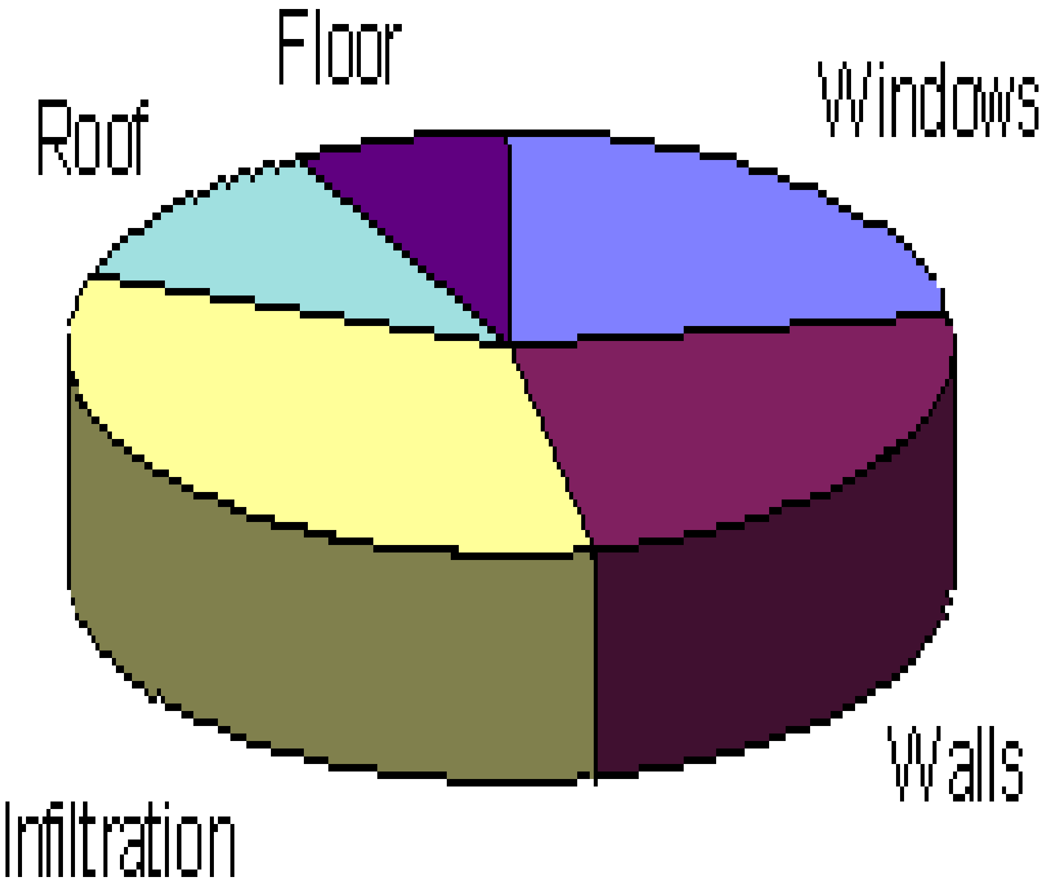
ICF vs. Wood Frame Structures

- According to an independent study/comparison referred to by the Portland Cement Association, analyses show that energy for heating and cooling account for 20-72% of the total annual energy costs, depending on the location of the structure.
- Due to the thermal mass of the concrete walls, houses with concrete walls have lower heating and cooling costs than houses with conventional frame walls, except for locations where the concrete walls were extremely under-insulated.

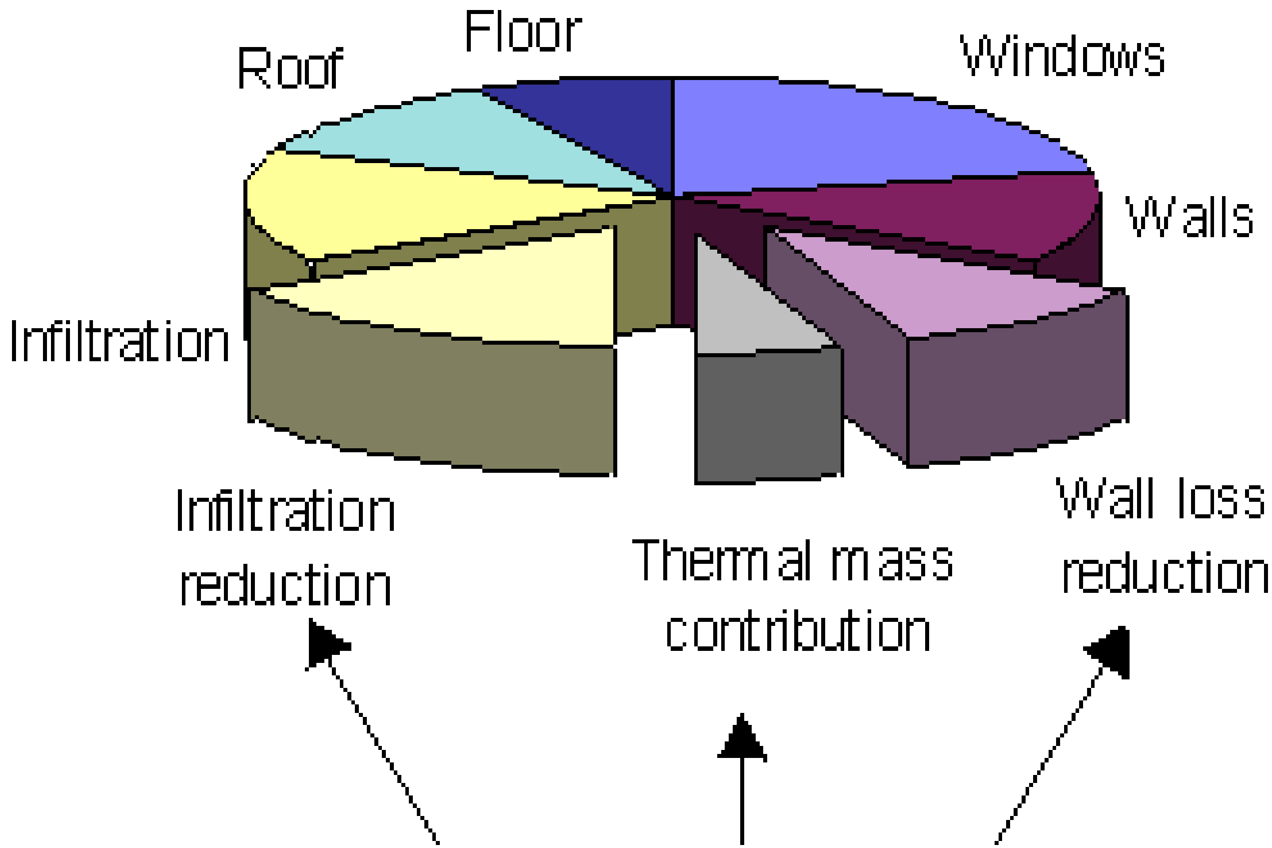
Reducing Energy Losses via ICF

- ICF construction can reduce energy losses resulting from stick-frame construction by up to 80%:
  - Up to 35% reduction due to decreasing infiltration/convection via concrete
  - Up to 35% reduction due to reducing conduction in envelope (continuous EPS foam insulated concrete walls, floors and ceiling)
  - Up to 10% reduction due to increasing thermal mass via concrete floors

Stick-Frame Energy Losses



ICF Energy Loss Reductions



Over 80% Total Energy Reduction by adding ICF Radiant Floors & ICF Dutch-Hip Roof Structures

R-9 Passive Windows & ICF Structures

- Internal ICF bucks, OSB framing, quadruple glazing, state-of-the-art fiberglass frame, and expansion foam insulation provides unprecedented energy efficiency for windows and doors.
- Strategic window placement and glass treatments coupled with strategic eaves and shades for capitalizing on passive solar radiation and thermal mass of concrete can reduce energy loss by another 10-20% for ICF structures.

Insulated Concrete Forms

- ICF technology integrates concrete with foam insulation, providing up to R-59 thermal heat efficiency in walls at a cost similar to conventional 2x6 wood frame and fiberglass (batting) insulation construction, but with the following advantages:
  - Energy savings up to 80% through tighter envelope
  - Increasing thermal mass via ICF, masonry or concrete exterior, concrete floors, optimizing solar radiation during cool seasons, and minimizing solar radiation during warm seasons (passive solar house)
  - Relatively short time of installation
  - Ease of maintenance and longevity (mold proof EPS foam and concrete)
  - Soundproofing
  - Earthquake and hurricane/tornado proof construction

ICF Construction Benefits

Short Term Benefits

- Reduce required cooling tonnage by over 90% for strategic passive cooling
- Shorten construction time
- Fit any design with ease
- Reduce worker injuries with lightweight materials
- Lower labor costs with smaller crews

Long-Term Benefits

- Lower maintenance and lifetime operating costs with higher energy efficiency
- Profit from cleaner, quieter and more comfortable interiors
- Increase longevity and structural integrity
- Enhance security with greater fire resistance and storm safety

Energy Performance & R-Values of Insulated Concrete Forms

- Fact or Fiction: "The R-value tells me how much energy my house will use, right?"
- R-value measures the resistance a material has to heat transfer (conductance), this much is true. R-value alone, however, does not fully describe the energy performance of a building.
- Everyone in the ICF community knows that ICF buildings far outperform framed buildings with comparable stated R-values in terms of energy efficiency and comfort level, but why is that?

Energy Performance Factors

- The main factors affecting actual energy performance of a building are:
  - Thermal Conduction
  - Thermal Convection
  - Thermal Radiation
  - Thermal Mass
- Each of these energy factors must be considered when planning and building an energy efficient structure.

Thermal Conduction

- Thermal conduction is the heat transfer through a material by contact of one molecule to the next. This is the only factor an R-value measures.
- However, as indicated above, thermal conduction is not the only mode of energy loss in a building.
- In fact, conduction contributes less to energy losses in wood frame buildings than convection which is not measured by R-values.

Wood Framing & Thermal Conduction

- We have all heard builders claim to build "R-13" or "R-21" walls with wood frame construction.
- The problem with those claims is that only the highest rated component in the walls - the insulation itself - performs at these stated R-values.
- A wood frame wall is made up of several components, not all of which have the same R-value. For instance, a 2x4 or 2x6 stud has an R-value of only about R-5 or R-7.

Wood Framing & Thermal Conduction Cont.

- Every 16 inches or so, one of these components breaks the insulation layer and forms a 'thermal bridge', conducting heat through the walls at high rates. Adding up the area of studs, plates, and headers, *12-16% of the total wall area is an R-5 or R-7 thermal bridge*, all detracting from the stated R-value.
- In addition, batt insulation tends to sag over time and leave spaces without any insulation! How can those builders claim only the highest component R-value? From a 'whole-wall' perspective, framed walls operate at far lower R-values.

ICF & Thermal Conduction

- Most ICF walls consist of two layers of EPS, with a center cavity to contain concrete.
- The EPS remains in place after pouring concrete to provide two largely <u>*uninterrupted layers of insulation*</u> rated at roughly R-20 or higher.
- From a 'whole-wall' perspective, an ICF wall actually lives up to the stated R-values because thermal bridging is minimal.

ICF Technology Advantages

- Ultra Energy-Efficient because of continuous EPS insulation (higher & uniform R-value), greatly reduced air infiltration, and the thermal mass effect of concrete.
- Much more Comfortable and Healthy because of even inside temperatures (no cold spots or nasty drafts), far better sound attenuation, and low risk of mold growth and allergen infiltration.
- Longer-lasting and more resistant to natural disasters, rot, mold, and pests because the solid reinforced concrete is up to 8 times stronger and nearly impenetrable (even for car crashes) - it's what gives bunkers their strength!

Thermal Convection

- Thermal convection is heat transfer by movement of currents within fluids (or gases).
- When considering energy performance of buildings, it's the air moving between the inside and outside or 'air infiltration'.
- A common measurement is 'Air Changes per Hour' at a blower-door induced pressure differential of 50 Pascal (ACH50).
- US Energy Star standards for new homes require less than 4-7 ACH50.
- By comparison, British standards are 3-5 ACH50, Canadian R-2000 standards are 1.5 ACH50, and Swedish standards are 0.5 ACH50 or less.

Wood Framing
& Thermal Convection

- In wood frame buildings convection can be felt as ‘drafts’. It is usually the biggest source of energy loss in a structure.
- Air infiltration accounts for *up to 40% of the energy losses* of a wood-framed structure.
- Heat is carried by *air leaking through thousands of cracks*, openings, and joints between all the pieces of the building shell.

Wood Framing & Thermal Convection cont.

- Major culprits include framing connections, wall, floor & roof intersections, shrinkage of wood and caulking, and poor installation of components and sealants.
- A typical new wood frame home has between 1.75 and 3 air changes per hour (ACH50). As the wood shrinks and sealants deteriorate, the ACH50 drops to <u>*between 5 and 10 ACH50*</u> in subsequent years.
- Old wood frame homes commonly have 10 to 20 ACH50.

ICF Thermal Convection

- ICF walls & roofs are an effective air barrier because the concrete is poured in semi-liquid form, forcing air out of the cavity and filling every void after consolidation.
- A chemical reaction turns the concrete into <u>*a solid without passages for air to leak*</u>, thus eliminating a major percentage of air infiltration.
- ICF homes consistently perform at <u>*0.5 to 2.5 ACH50 and less*</u>, largely depending on the installed roof type and proper sealing of the structure/envelope.

ICF Thermal Convection cont.

- Most air infiltration in an ICF home is through a conventional roof and around windows & doors.
- Using ICF such as Quad-Deck for the roof (which converts wasted attic space into value added living space) can allow for achieving <0.5 ACH50 in conjunction with proper installation, sealing, and insulation of passive windows and doors.
- Energy or heat-recovery ventilators (ERV or HRV) will be used to eliminate exterior exhaust vents, providing further energy savings and allowing adequate air exchange in extremely airtight buildings.

Thermal Radiation

- Thermal radiation transfers heat via electromagnetic waves, which for buildings are mostly the sun's rays.
- Depending on factors like site & location of the building and the prevailing climate, Passive Solar Building Design helps optimize a building's absorption and reflection of solar radiation through strategic solar orientation, placement of windows and shading elements, choice of finishes, and incorporation of thermal mass.

Thermal Mass

- Thermal mass refers to a material's capacity to store heat, e.g., heat capacity. Concrete, cultured stone, and (adobe) bricks have high thermal mass, which can act like a battery for storing thermal energy.
- The classical use of thermal mass is in desert climates (including Boise, ID), where outside temperatures swing above inside temperatures during the day and below at night.

Thermal Mass cont.

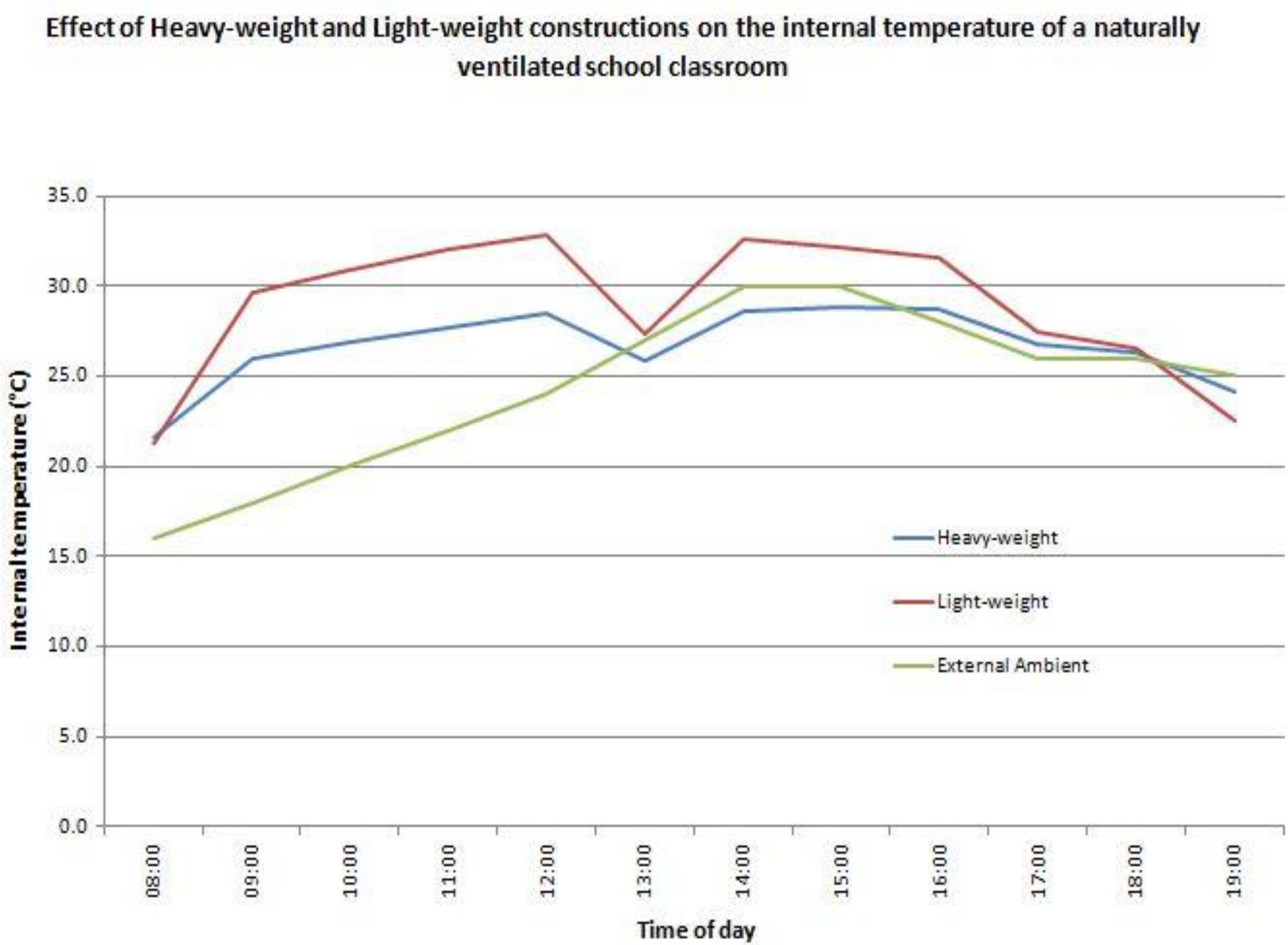
- High mass building shells can store the heat from the outside during the day and release that heat to the inside at night - keeping the inside comfortable (using almost no additional energy).
- In temperate climates, thermal mass is best used in combination with the principles of passive solar design, e.g., allowing the sun to heat high thermal mass (concrete) floors and connected structures through strategically placed windows during cool seasons.

Thermal Mass & Building Design

- **Thermal mass** is a concept in building design that describes how the mass of the building provides "inertia" against temperature fluctuations, sometimes known as the **thermal flywheel effect**.
- For example, when outside temperatures are fluctuating throughout the day, a large thermal mass within the insulated portion of a house can serve to "flatten out" the daily temperature fluctuations, since the thermal mass will absorb thermal energy when the surroundings are higher in temperature than the mass, and give thermal energy back when the surroundings are cooler, without reaching thermal equilibrium.

Thermal Mass

- Is distinct from a material's insulative value, which reduces a building's thermal conductivity, allowing it to be heated or cooled relatively separate from the outside, or even just retain the occupants' thermal energy longer.
- Scientifically, thermal mass is equivalent to **thermal capacitance** or **heat capacity**, the ability of a body to store thermal energy.


Effect of Heavy-weight and Light-weight constructions on the internal temperature of a naturally ventilated school classroom
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Internal temperature (°C)
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
Time of day
Heavy-weight
Light-weight
External Ambient

Understanding the Properties of Thermal Mass

- Though thermal mass has always been an aspect of buildings, only in recent years has it evolved as a tool to be deployed in the conservation of energy.
- Understanding the properties of thermal mass and its use, particularly in context, is critical to realizing both benefits and potential pitfalls.
- This understanding begins with the concept of thermal admittance.

Thermal Admittance

- Thermal admittance (aka heat transfer coefficient) quantifies a material's ability to absorb and release heat from a space as the indoor temperature changes through a period of time.
- Admittance values can be a useful tool in the early stages of designing a building or structure when assessing heat flows into and out of thermal storage.

Thermal Admittance Calculation

Thermal Admittance is measured in $W/(m^2K)$. So that

$$\mathbf{h = \Delta Q / A \times \Delta T}$$

h = heat transfer coefficient, $W/(m^2K)$
ΔQ = heat input or heat lost, W
A = heat transfer surface, m^2
ΔT = difference in temperature between the solid surface and the adjacent air space.

Thermal Admittance Values

- Higher admittance values indicate higher thermal mass.
- Thermal admittance is fully described in EN ISO 13786:2007.
- The framework described also provides the basis for the CIBSE 'Simple Dynamic Model' for calculating cooling loads and summertime space temperatures (CIBSE (2005) Guide A: Environmental design).

Admittance Values for Typical External Wall Elements (based on a 24 hr. cycle)

External wall	Internal finish	Admittance value
Timber frame (brick outer leaf)	Plasterboard	1.0
	Wet plaster	
Masonry cavity wall (100mm aircrete block)	Plasterboard	1.85
	Wet plaster	2.65
Masonry cavity wall (100mm dense aggregate block)	Plasterboard	2.65
	Wet plaster	5.04

Source: The Concrete Centre (calculated according to EN ISO 13786:2007)

Factors that Determine Thermal Mass

- Specific Heat Capacity
- Density
- Thermal Conductivity

Specific Heat Capacity

- Specific heat capacity refers to a physical material's capacity to store heat for every kilogram of mass contained in that material.
- A material of 'high' thermal mass has a high specific heat capacity.
- Specific heat capacity is measured in J/kg.K

Density

- The density refers to the mass (or 'weight') per unit volume of a material and is measured in kg/m^3.
- A high density material maximizes the overall weight and is a characteristic aspect of 'high' thermal mass.

Thermal Conductivity

- Thermal conductivity measures the ease with which heat can travel through a material.
- For 'high' thermal mass, thermal conductivity usually needs to be moderate so that the absorption and release of heat synchronizes with the building's heating and cooling cycle.
- Thermal conductivity is measured in units of W/m·K

Effectiveness of Thermal Mass for Common Building Materials

Material	Specific heat capacity (J/kg K)	Thermal conductivity [W / (m · K)]	Density (J/kg K)	Effectiveness
water	4200	0.60	1000	high
stone	1000	1.8	2300	high
brick	800	0.73	1700	high
concrete	1000	1.13	2000	high
unfired clay bricks	1000	0.21	700	high
dense concrete block	1000	1.63	2300	high
gypsum plaster	1000	0.5	1300	high
aircrete block	1000	0.15	600	medium

SAP & Thermal Mass

- SAP 2009 uses thermal mass in calculating the heating and cooling load of a building.
- SAP uses the kappa (k) value to determine thermal mass. 'k' is the measure of the heat capacity per unit area in kJ/m^2K of the 'thermally active' part of the construction element:

  $$\mathbf{k = 10^{-6} \Sigma_i p_i c_i d_i}$$

p_i = the density of the layer 'i' in the construction (kg/m^3)
c_i = the specific heat capacity of the layer 'i' (J/kg K)
d_i = the thickness of the layer 'i' (mm)

Kappa Value Equation

- The calculation is performed over all the layers of the construction element, starting at the inside surface and stopping at whichever of these conditions occurs first (including its occurrence part-way through a layer):
  - half way through the construction
  - an insulating layer
  - a maximum thickness of 100mm

Thermal Mass Parameter

The kappa value is used in the calculation of the Thermal Mass Parameter (TMP):

TMP = Cm / TFA

Cm = sum of (area x heat capacity) construction elements
TFA = total floor area

The 'k' value is a relatively crude way of determining thermal mass. It makes assumptions about the extent of the thermally active volumes of a material and ignores the effect of thermal conductivity in calculating the period over which heat is absorbed and emitted from the material.

ISO 13786 provides a more effective method of determining thermal mass for materials including wall, floor and ceiling construction.

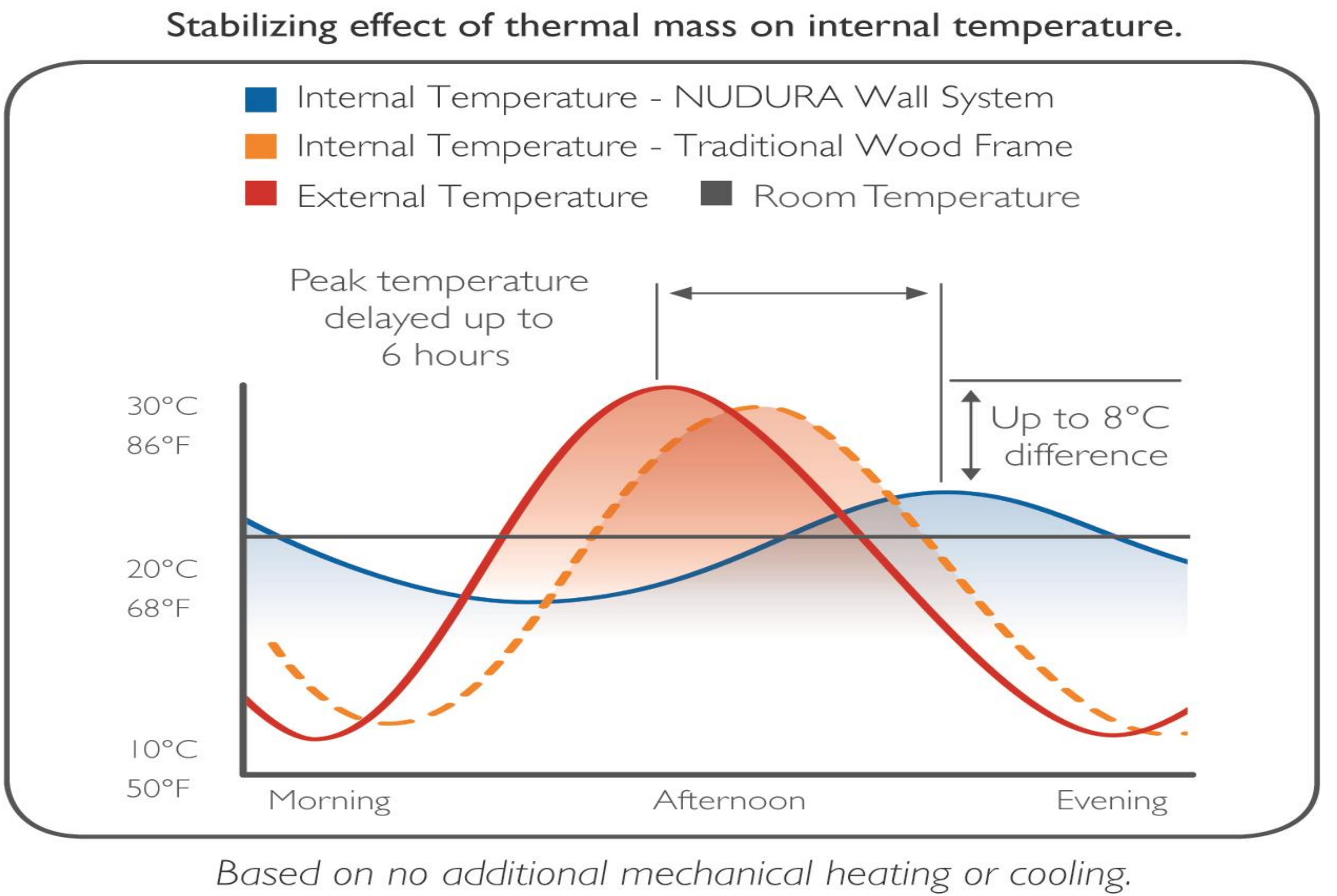
How Thermal Mass Works

- By alternately storing and releasing heat, high thermal mass 'smooths out' the extremes in daytime temperatures.
- In warm/hot climates where there is significant temperature variation between day and night ('diurnal' variation), heat is absorbed during the day and then released in the evening when the excess can be either 'flushed out' through natural ventilation or it can be used to heat the space as the outside temperature drops.
- The entire process can then be repeated the next day.

Thermal Mass of Concrete vs. Wood

- Wood frame buildings have almost *no thermal mass* - unless the exterior walls are finished with concrete products, brick or other masonry product.
- In contrast, concrete has a relatively high ability to store and release thermal energy.
- This makes concrete an ideal building material for use in passive house design, particularly for passive solar radiation.

ICF Exterior Wall System



High Heat Capacity & Moderate Conductivity

- ICF exterior structure walls and connected floors have a high storage capacity with moderate thermal conductivity. Thus, it provides the most useful level of thermal mass sandwiched between EPS foam layers.
- This helps to stabilize the internal temperature from day to night temperature fluctuations.
- Increasing thermal mass by constructing interior walls, floors, ceilings and roofs with ICF and concrete slabs could substantially increase energy conservation.

Capitalizing on Concrete Thermal Mass

- Concrete walls conserve heat or cooling, acting as an energy sink. According to the Portland Cement Association this contributes/comprises about 6% of the needed energy for a structure.
- Based on thermal mass, when floors, interior walls, and roof structure are also constructed of ICF, passive solar radiation and the concrete structure can combine to contribute over 24% of the needed energy of the structure.
- Concrete floors, concrete countertops, strategic concrete eaves, and passive solar window/glazing design could potentially provide over 40% of the volume of energy required for the PHMH.

ICF Thermal Mass

- High mass construction built into ICF walls & floors can significantly reduce the requirements for active heating and cooling systems in many climates.
- This translates into *on-going energy savings from using smaller sized HVAC equipment*.
- Most current residential HVAC sizing software programs do not factor in the effects of thermal mass.

Concrete Thermal Mass

- Concrete “thermal mass” provides the ability to smooth out large temperature swings.
- It keeps the walls warmer when the outdoor temperature reaches its coldest extreme and cooler when the outdoor temperature is hottest.

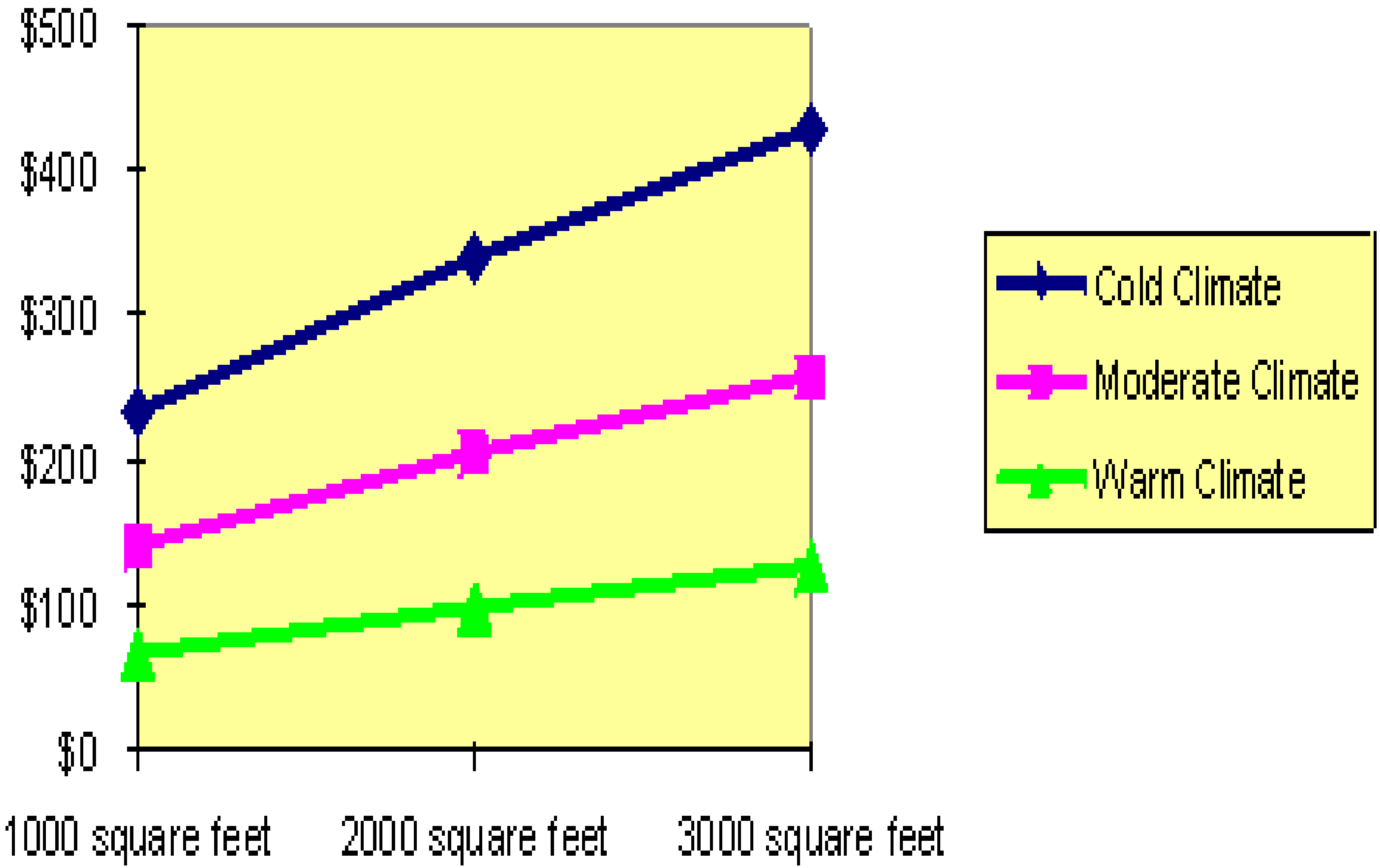
Concrete Homes Save Energy

- According to the Portland Cement Association, building a concrete home with ICFs saves energy and money.
- The greater insulation, tighter construction and temperature-moderating mass of the walls conserve heating and cooling energy much better than conventional wood-frame walls.
- This reduces monthly fuel bills. It also allows use of smaller heating and cooling equipment, saving money in construction.

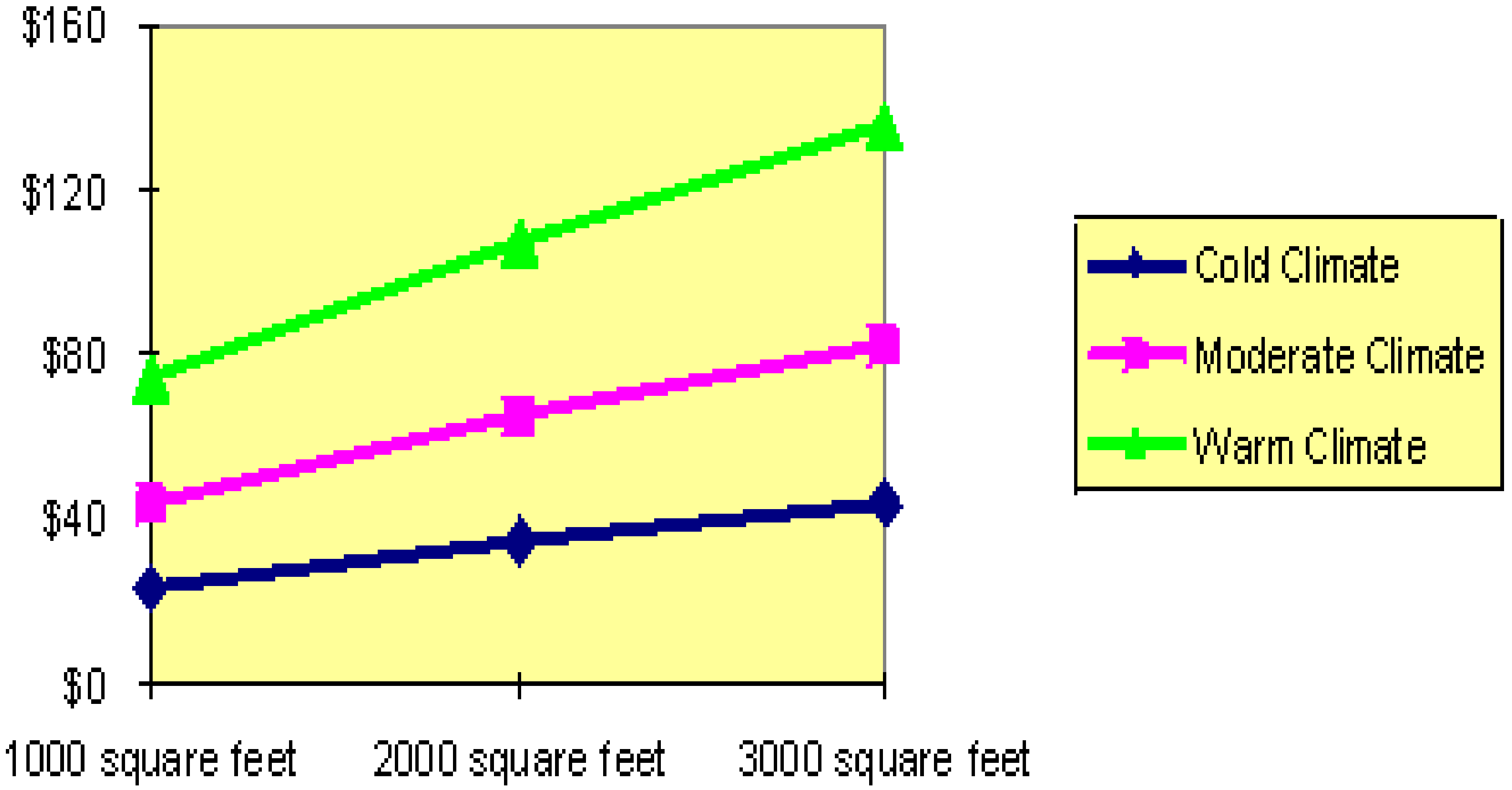
Concrete Homes Save Energy cont.

- Houses built with ICF exterior walls require an estimated 44% less energy to heat and 32% less energy to cool than comparable frame houses. A typical 2,000 square foot home in the center of the U.S. will save approximately $200 in heating costs each year and $65 in air conditioning each year.
- The bigger the house, the bigger the savings. In colder areas of the U.S. and Canada, heating savings will be more and cooling savings less. In hotter areas, heating savings will be less and cooling savings more.

Estimated Annual Heating Savings



Estimated Annual Cooling Savings



Energy Savings Estimates

- The above energy savings estimates are from a study of 58 single-family houses across the US and Canada.
- Half had exterior walls constructed with concrete using ICFs made of expanded polystyrene (EPS) or extruded polystyrene (XPS) foam.
- The other half were neighboring houses with wood-frame walls. All houses were less than 6 years old.

Reducing Energy Consumption

- Researchers compared the energy bill of each concrete house to its frame counterpart, carefully correcting for important differences to get an “apples-to-apples” comparison.
- Estimates of equipment savings are actual numbers reported by contractors who build ICF houses.
- Insulating values for ICF walls using polystyrene foam are R-17 to R-26, compared to wood frame’s R-9 to R-15. ICF walls are expected to cut conduction losses through foundation and above-grade walls in half. And ICF walls are tighter. In tests, they averaged about half as much infiltration (air leakage) as wood-frame homes.

PHMH Construction

- Since the PHMH will have ICF exterior walls, interior walls, slab floors, and roof, it will have nearly double the insulation [e.g., R-51 in walls and R-80 (R-16 Quad-Deck panel plus R-65 (16” Foam-Control EPS including ¾” OSB coverboard] in the roof, the increase in energy conservation will be over double that of the ICF houses in the above study.
- In addition, conduction will be virtually eliminated through an air-tight ICF envelope. Thus, the volume of savings for the PHMH will be substantially enhanced in relation to the above comparisons.

Benefits of Interior ICF Walls

- Sound attenuation
- Mold and mildew free environment
- Structural support for ceiling, floors, roof and exterior walls
- Fire resistance (fire protection rating up to 4 hr. via steel reinforced concrete and a non-toxic fire retardant EPS foam)
- Ease of installation and construction including plumbing, electrical, and HVAC, etc.
- Green building & longevity
- Increase in thermal mass

Net-Zero PHMH

- By virtually eliminating energy losses due to convection and using super-insulated ICF, the primary objective of the PHMH is to decrease the energy load by over 90%. This will reduce HVAC sizing proportionately.
- Structure orientation, strategic glazing, and passive solar radiation will then be utilized in conjunction with solar/PV power systems to achieve a Net-Zero PHMH.

Smaller Energy/HVAC Loads

- Since the energy needed is less, HVAC requirements are also less. And the more the energy savings, the greater the possible reduction in equipment size —and cost.
- Estimating the size of heating and cooling equipment for concrete homes is complicated because the effect of thermal mass must be simulated in a computer program.
- The Building Energy Optimizer modeling software, Energy Plus Simulation Software (developed by NREL) and WrightSoft HVAC software simplify manual J & D calculations by entering information about the house including location, house size and wall, floor, and roof construction, etc.

HVAC Sizing Software

- BEopt and Wrightsoft’s sophisticated HVAC design software use Dept. of Energy 2.1E calculations to estimate the required heating and cooling system capacity (Manual J) for single-family concrete homes.
- Calculations are based on a user-defined thermostat set point, house dimensions, construction materials, and geographical location.

Summary of ICF vs. Wood Frame

- The R-value of one component alone does not reveal how a building will perform. The Building Code is only a MINIMUM standard, and there are many factors that influence energy performance.
- ICF buildings far outperform framed buildings despite similar stated R-values.
- The secret lies in the combination of reduced conduction & convection, and high thermal mass.
- The result is ICF buildings have lower appetites for energy and more consistent and comfortable temperatures inside the building.

PHMH Strategy

- NREL's Building Energy Optimizer (BEopt) modeling software and EnergyPlus simulation software will be utilized to optimize energy conservation and reduce energy loss through tight ICF construction, superinsulation, southern orientation, and strategic glazing, etc.
- Integration of passive solar radiation and the relatively high thermal mass of exclusive ICF structures including radiant floors allows for providing unprecedented energy conservation.

State-of-the-Art
Modeling & Simulation Software

- The PHMH will be designed using BEopt modeling software and the EnergyPlus simulation engine developed by DOE’s National Renewable Energy Lab (NREL).
- This software is publicly available and is constantly being updated and improved, the goal of which is to assist builders and homeowners to achieve unprecedented levels of energy efficiency in an affordable manner.

Achieving Net-Zero Energy (NZE)

- BEopt is a computer program designed to find cost-optimal building designs along the path to a zero net energy (ZNE) building.
- A zero net energy building produces as much energy as it uses on an annual basis, using a grid-tied, net-metered photovoltaic (PV) system and active solar.
- The optimal path to ZNE extends from a base case to the ZNE building through a series of energy-saving building designs with minimal energy-related costs.

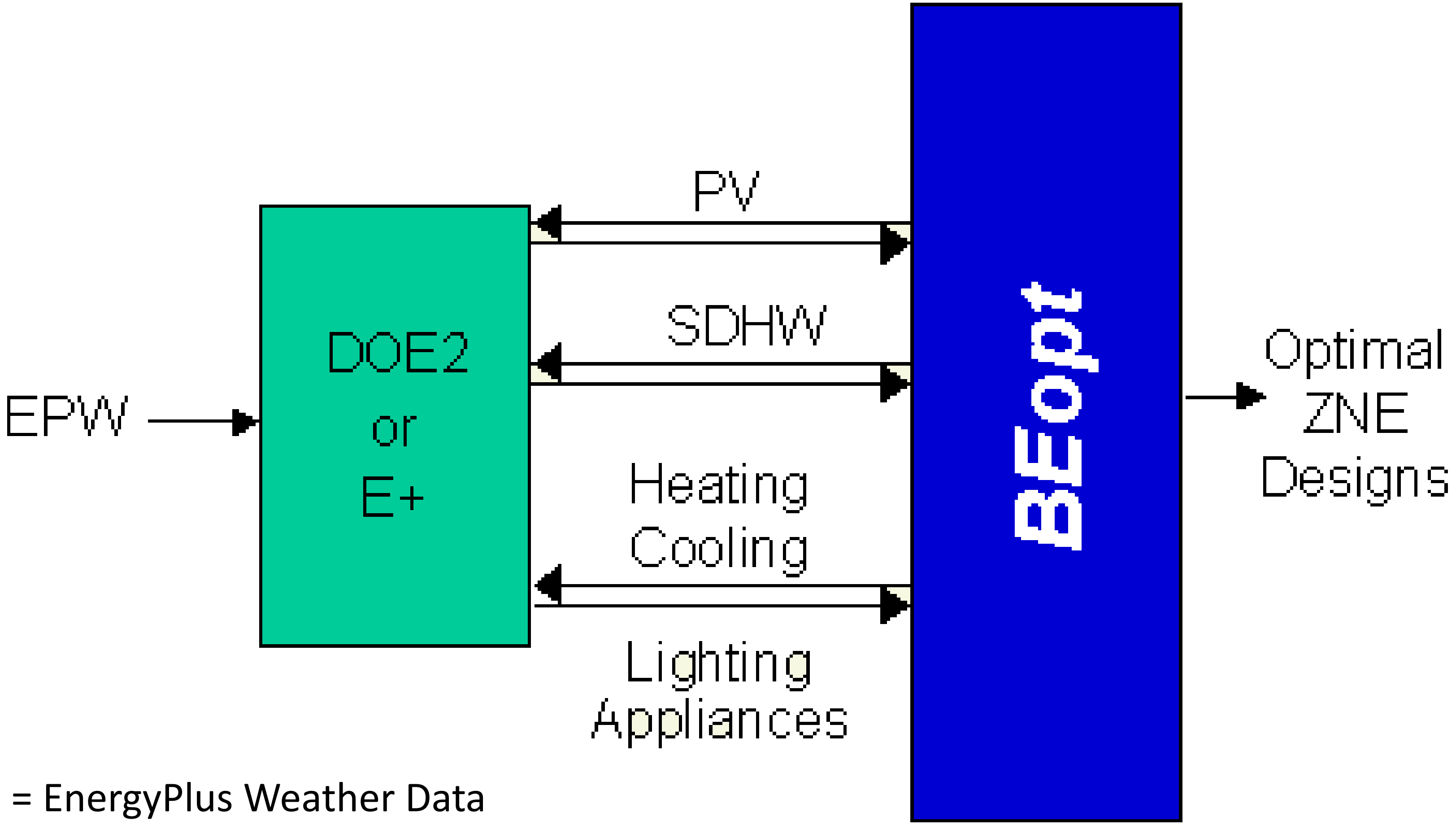
BEopt Modeling Software

- In BEopt, a user selects from predefined options in various categories to specify options to be considered in the optimization.
- Energy savings are calculated relative to a reference. The reference can be either a user-defined reference, a climate-specific Building America Benchmark for new construction, or an Existing (w/ Min Replace) reference for retrofit.
- The user can also review and modify detailed information on all available options via the library management tools.

DOE2 or EnergyPlus Simulation Engines

- BEopt calls the DOE2 or EnergyPlus simulation engines and uses a sequential search technique to automate the process of identifying optimal building designs along the path to ZNE.
- BEopt finds these optimal designs based on discrete building options reflecting realistic construction options.
- BEopt handles special situations with positive or negative interactions between options in different categories.

BEopt & E+ Flow Chart



EPW = EnergyPlus Weather Data
PV = Photovoltaic Power System
SDHW = Solar Domestic Hot Water

Output Screen

- The BEopt software includes an output screen that allows the user to navigate among different design points and retrieve detailed results regarding energy end-use and option costs in different categories.
- Multiple cases, based on a selected parameter such as climate, can be included in a BEopt project for comparative purposes.

Modes of Analysis

- Currently there are three modes of analysis: design mode, parametric mode, and optimization mode.
- Design mode allows the user to perform a set of building design simulations for analysis.
- Parametric mode allows the user to quickly perform traditional parametric analyses.
- Optimization mode, on the other hand, sequentially searches the available building options for the lowest cost building designs at various levels of energy savings.

Minimizing PV Investment

- Before investing in photovoltaic technology to produce a home's energy, it is more cost-effective to first use energy efficient measures to minimize the energy that must be produced.
- In this way, a smaller, less expensive PV array can meet the home's energy needs.

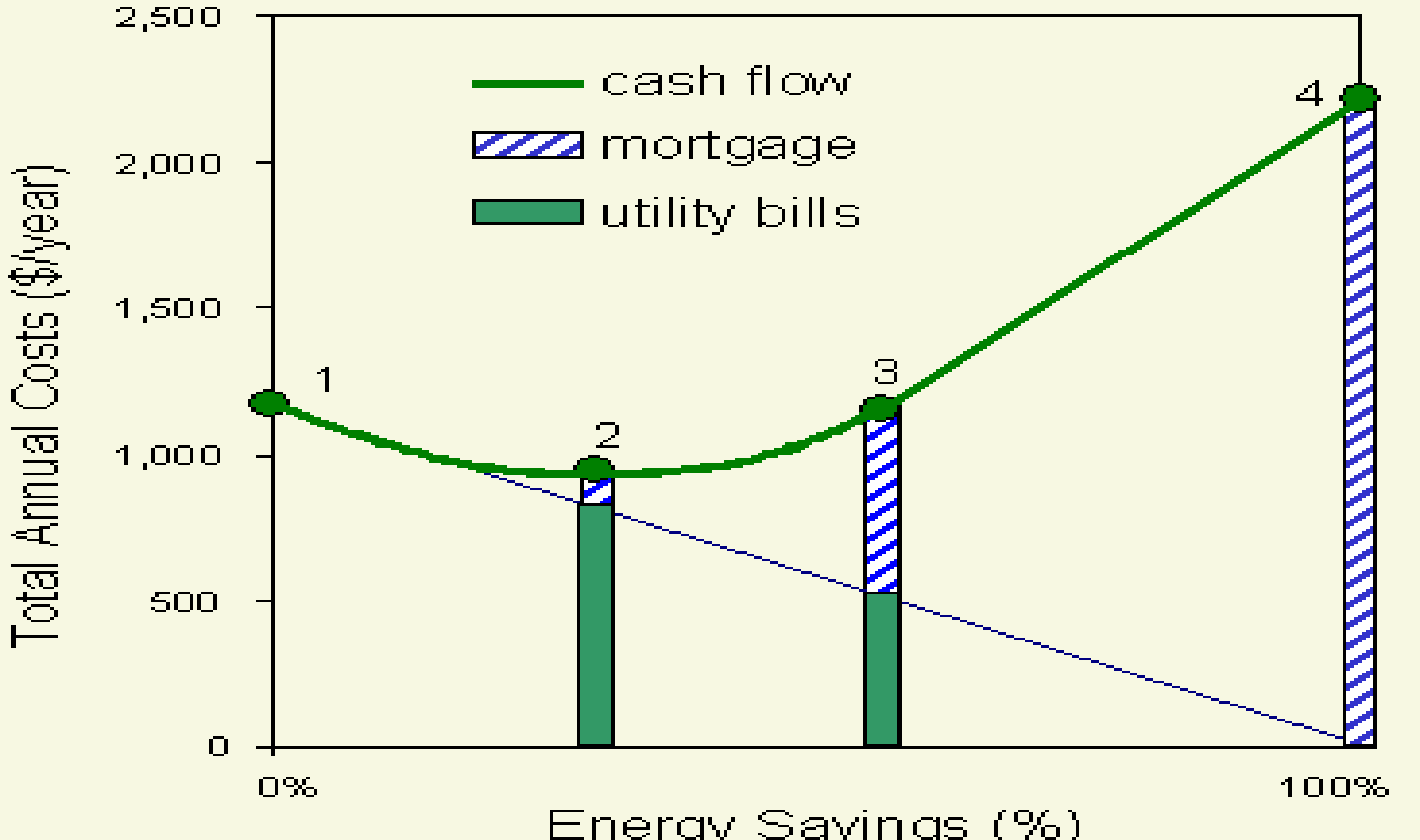
Path to Zero Net Energy

- BEopt produces a graph referred to as the Path to Zero Net Energy. This Path can answer the following questions:
  - How much should be invested in efficiency before investing in PV?
  - What is the optimal configuration of energy efficiency measures?
  - What if only a partial reduction in energy use (from a reference case) is desired?

Path to Zero Net Energy cont.

- The following sketch illustrates the concept of a building's path to zero net energy.
- The path falls on a graph of the % energy savings along the x-axis, and the annualized energy costs on the y-axis.
- This annual cost is made up of both the energy costs each year plus the cost of energy efficiency measures that have been incorporated into the mortgage payments.

Path to Zero Net Energy Graph



PHMH Objectives

- BEopt and EnergyPlus software will be used to achieve one of the primary objectives of the PHMH, e.g., initial planning and design.
- This will include analysis and adoption of leading edge technologies in conjunction with construction management techniques that will provide a paradigm shift in:
  - Energy Efficiency
  - Quality
  - Affordability

Passive Building Design

- Every building must be considered from a 'whole system' perspective.
- In addition to walls, roof and slab, windows have a significant impact on performance.
- Windows usually make up 10-20% of the total wall area and range widely in energy efficiency.

Building Envelope & Computer Analysis

- Building envelope consultants now offer modeling services (such as BEopt and Energy Plus) that provide an accurate picture of how a building will actually perform after construction.
- This small investment in computer analysis assists in formulating the most energy efficient design in order to save tens of thousands - even hundreds of thousands - in energy costs over a building's lifetime.

Green Building & Passive House Design

- Sustainable or green building practices promote the construction of buildings that are healthier for the occupants and healthier for the environment.
- They reduce the tremendous impact that building construction, operation, maintenance, and disposal have on both people and nature.
- According to the US Department of Energy's Center for Sustainable Development, buildings consume 40-50% of the world's total energy, 25% of its wood harvest and 16% of its water.
- The building industry is the nation's largest manufacturing activity, representing more than 50% of the nation's wealth.

Green Building & ICF Technology

- A recent report by the Commission for Environmental Cooperation (CEC) promotes Green Building for the Biggest, Easiest Cuts in CO_2 Emissions.
- Energy-saving technologies applied in buildings can result in enormous reductions in demand for fossil fuels and emissions of greenhouse gases.
- ICFs are a key technology because they provide an ultra-efficient, high mass, high strength, and a very tight, durable building shell that keeps occupants healthy and comfortable while having a very small environmental footprint.

Boise, ID Passive House Planning

- Boise, ID is located in a zone 5 desert environment with temperate climate.
- Summers are typically hot and dry from July to September with a relatively large temperature swing in the evenings.
- The summer temperature swing is ideal for capitalizing on cooling the interior of the structure during the evenings/early mornings.
- The angle of the sun in the summer and winter is ideal for capitalizing on solar passive gain in the winter.

Passive House Planning

OFFICIAL CLIMATE DATA SET - PHIUS

METRIC:

Month	11	12	Heating Load		Cooling Load
Days	30	31	Weather 1	Weather 2	Radiation
BOISE AIR TERMINAL [UO] ID	Radiation Data:	kWh/(m²*month)	Radiation: W/m²		W/m²
Ambient Temp (°C)	4.0	1.9	-9.9	4.0	27.5
North	18.0	17.0	39.0	16.0	82.0
East	39.0	34.0	78.0	25.0	204.0
South	93.0	89.0	179.0	43.0	145.0
West	40.0	34.0	71.0	23.0	195.0
Global	55.0	44.0	85.0	33.0	330.0
Dewpoint	-1.9	-3.3			
Sky temperature	-10.2	-12.3			

US CUSTOMARY:

Month	11	12	Heating Load		Cooling Load
Days	30	31	Weather 1	Weather 2	Radiation
BOISE AIR TERMINAL [UO] ID	Radiation Data:	kBTU/(ft².month)	Radiation: BTU/hr.ft²		BTU/hr.ft²
Ambient Temp (°F)	39.2	35.4	14.2	39.2	81.5
North	5.7	5.4	12.4	5.1	26.0
East	12.4	10.8	24.7	7.9	64.7
South	29.5	28.2	56.7	13.6	46.0
West	12.7	10.8	22.5	7.3	61.8
Global	17.4	13.9	26.9	10.5	104.6
Dewpoint	28.6	26.1			
Sky temperature	13.6	9.9			

Passive House Design Requirements

- Total heating & cooling demand of <15 $kWh/m^2/yr$ (4.7 $kBtu/ft^2/yr$)
- Total primary (i.e., source) energy of <120 $kWh/m^2/yr$ (38 $kBtu/ft^2/yr$)
- Air-tightness <0.5 ACH@50 Pa or less
- Peak heating demand <10 W/m^2 (3.2 Btu/ft^2)
- Total site energy of <42 $kWh/m^2/yr$ (13.3 $kBtu/ft^2/yr$)
- Window U_{si}-values of <0.8 W/m^2K (0.15 $Btu/ft^2/F$, R_{ip}-7.1)
- High-efficiency heat recovery (over 80%)

Passive House
U-value Requirements

- The International Passive House requirement for U-values is typically in the 0.10 to 0.15 W/(m².K) range).
- In Sweden, to achieve passive house standards the U_{si}-value is 0.066 W/(m².K)).
- In Boise, ID, to achieve passive house standards the insulation U_{si}-value target is <0.12.

SI & IP Standards for R-Values and U-Values

- Around most of the world, R-values are given in SI units (International System of Units), typically square-metre kelvins per watt or $m^2 \cdot K/W$ (or equally, $m^2 \cdot °C/W$).
- In the United States customary units, R-values are given in units of $ft^2 \cdot °F \cdot hr/Btu$.

SI & IP Conversion Formula

- It is particularly easy to confuse SI and US/North American R-values (IP), because R-values both in the US and elsewhere are often cited without their units, e.g., *R-3.5*.
- Usually, however, the correct units can be inferred from the context and from the magnitudes of the values. United States and North American R_{ip}-values are approximately six times R_{si}-values.
- The specific conversion formula is: U_{si}= U_{ip}*5.678263.

Boise, ID
Passive House Objectives

- Insulation, >R_{ip}-51 (<U_{si}-0.111) walls, R_{ip}-80 (U_{si}-0.0710) roof, quadruple-glazed R_{ip}-9 low-e windows, and elimination of thermal bridges via ICF construction (exterior foam and interior concrete).
- Ultra-airtight construction (<0.5 ACH@50) and U_{si}-value wall requirements (<0.12) will be accomplished using a rectangular structural shape with southern orientation.

Boise, ID Passive House Objectives cont.

- Normally R_{ip}-45 (U_{si}-0.1262) sub-slab insulation is recommended for passive house design.
- However, for the desert environment cool soil temperature at a constant 55 °F provides a strategic advantage for passive cooling of structures in the summer without significantly affecting winter heating loads.
- Hence, insulation in the basement floor slab can potentially be eliminated (or install radiant heating and cooling using R_{ip}-34 Quad-Deck).

Boise, ID Passive House Objectives cont.

- Passive solar gain for a portion of the heating will be achieved by orienting the house to the south and using an Alpen passive window solar heat gain coefficient (SHGC) score of 0.60.
- UltimateAir RecoupAerator ERV to reach 96% efficiency, with supply air to each space and return air pathways.
- Radiant floors and supplemental forced air using small duct high velocity (SDHV) system in conjunction with a hydronic heat pump.

InsulStone R_{ip}-6

- Using insulated cultured stone and stucco products for the exterior of the PHMH will allow for increasing the total insulation value of walls from R_{ip}-45 (Quad-Lock panels) to R_{ip}-51 (U_{si}-0.1114) with finished exterior.

InsulStone Concrete Product Glued to Quad-Lock ICF Panel

Using a proprietary adhesive developed in collaboration with Dow Chemicals, it works equally well with either foam or cultured stone products.

Pull Test – 120 lb. psi – withstands hurricane strength winds

Quad-Lock ICF Technology

- Quad-Lock is ISO 9001 and 14001 certified to ensure and continually improve product and service quality, and have minimal impact on our environment.
- Quad-Lock ICFs are constructed of dense Expanded Polystyrene (EPS) foam insulation that is fire retardant and mold-free [includes injection molded high-density polyethelene cross ties spaced at 12" (305 mm) on center horizontally].

Quad-Lock Distribution & Training

- Quad-Lock will be contributing ICF materials for building and demonstrating a passive house design via a model home.
- RM Enterprises, LLC will become a distributor.
- RM Enterprises and general contractors certified in Quad-Lock technology will train other contractors and subcontractors on installation of ICF and other technologies utilized in the passive home/building design.

Quad-Lock ICF vs. Wood Frame Construction

- Ultra Energy-Efficient because of continuous EPS insulation (higher & uniform R-value), greatly reduced air infiltration, and the thermal mass effect of concrete.
- More comfortable and healthy because of even inside temperatures (no cold spots or nasty drafts), far better sound attenuation, and low risk of mold growth and allergen infiltration.
- Longer-lasting and more resistant to natural disasters, rot, mold, and pests because the solid reinforced concrete is up to 8 times stronger and nearly impenetrable (even for car crashes) - it's what gives bunkers their strength!

Quad-Lock ICF vs. other Insulating Concrete Forms

- Quad-Lock has the highest range of insulation values.
- Different combinations of Quad-Lock panel provide true R-Values of 22, 28, 30, 38, 43, 45, 53, and 59.
- Be wary of "effective R-Values" (often cited as R-50 for R-22 ICFs) which are unscientific and prohibited by advertising laws.

Quad-Lock ICF vs. other Insulating Concrete Forms Cont.

- Quad-Lock creates much less waste compared to ICF block systems because most parts that need to be cut can be reused in the same project (see Reduce, Reuse & Recycle Tips).
- Quad-Lock typically adds a **2-4%** waste factor in estimates (some installers can achieve 1% or less!), while many projects using ICF blocks need a **5-8%** waste factor - often not included in estimates.

Quad-Lock ICF vs. other Insulating Concrete Forms Cont.

- A price per square foot of forms is NOT suitable for comparisons because you need to add the waste factor, structural bracing for corners and angles, plywood wrap-arounds on openings, zip-ties or clips to hold ICF blocks together, method to align walls along top and bottom, etc. along with all the associated labor costs!

Quad-Lock ICF vs. other Insulating Concrete Forms Cont.

- Most Quad-Lock items are in stock ready for shipping whereas many competitors require long lead times to first produce what you order; in addition it means their forms are often still moist and not shrunk down to final size.
- Quad-Lock offers less thermal bridging because <u>internal buck-outs</u> are made easy. "External bucks" - the only option for most ICF blocks - create a significant thermal bridge around every window and door opening.

OSB for Door & Window Buck-outs

- For the PHMH, internal buck-outs and subsequent framing of windows and doors will utilize relatively higher R-values for oriented strand board (OSB) materials vs. conventional 2x6 or 2x8 fir or pine studs.
- Expanding spray foam will also be utilized to provide an air tight and well insulated installation of windows and door frames.

Quad-Lock ICF vs. other Insulating Concrete Forms Cont.

- Quad-Lock is highly versatile using standard parts. Quad-Lock can easily be shaped to form all the design elements of modern buildings - wide openings, arches, corners, <u>any angles</u>, and <u>real curves with almost any radius</u>.
- Quad-Lock produces a flat, solid concrete wall providing a constant thickness of concrete throughout the wall (no thin/thick sections like grid or post-and-beam systems).

Quad-Lock ICF vs. other Insulating Concrete Forms Cont.

- Quad-Lock is Code Approved.
- Quad-Lock provides a better surface for stucco application. Quad-Lock creates an all-foam surface compared to some ICF systems where the surface consists of both EPS and the material used for ties, making it tougher to finish it.
- Quad-Lock's unique and patented tie design offers low likelihood of problems by positively connecting the EPS panels at both the horizontal and vertical seams where the pressure during concrete placement is most likely to cause failures.

Quad-Lock ICF vs other Insulating Concrete Forms Cont.

- Quad-Lock has very strong corners because of ingenious metal brackets - no additional bracing or zip-ties needed!
- Quad-Lock costs less to ship and store compared to most ICF block systems because it is a flat panel & tie system.
- Up to 100% more wall area can be shipped per truckload. With Quad-Lock, you're not shipping air!

Quad-Lock ICF vs other Insulating Concrete Forms Cont.

- Quad-Lock is ISO 9001 and 14001 certified to ensure and improve product and service quality and minimal impact on our enviroment.
- Quad-Lock offers great technical and instructional support and material. Local dealers and distribution partners are equipped to answer your questions, prepare detailed estimates, and assist at the jobsite.
- Quad-Lock Field Representatives are also ready to assist with quantity pricing, job site training, product seminars etc. Their website, Installation Video, Product Manual, and other informative technical and promotional literature reveal exactly how to build with Quad-Lock.

Commercial & Multi-Story Advantages over other ICFs

- No other ICF can build around pre-tied rebar as easily as Quad-Lock.
- No other ICF can be assembled with as little laborers' exposure to the outside of a multi-story structure.
- Quad-Lock's unique Corner, Angle, and T-wall solutions allow building from the safety of the inside of the building. This minimizes the amount of outside scaffolding required and the risk of long falls for workers.

Commercial & Multi-Story Advantages over other ICFs

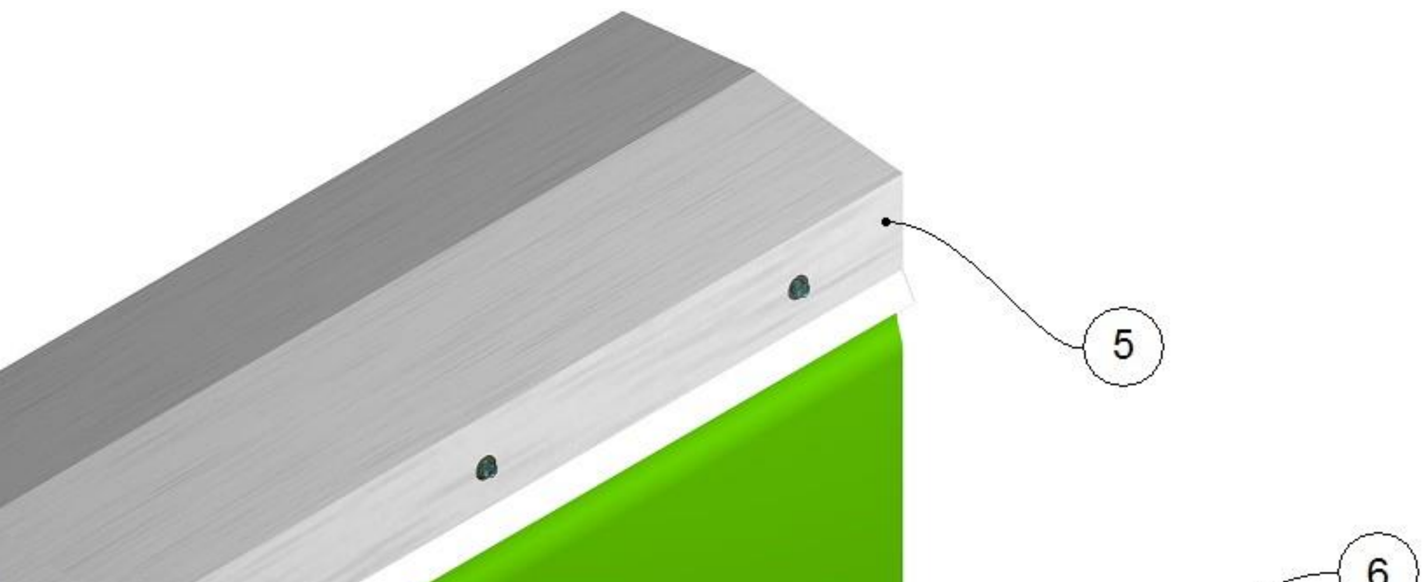
- No other ICF can build columns and pilasters like Quad-Lock. Almost every commercial project needs them.
- Few other ICFs can offer the range of wall thicknesses that Quad-Lock offers. See Quad-Lock Ties & Extender Ties.
- No other ICF can provide Quad-Lock's unlimited range of wall angles with so little labor.

Commercial & Multi-Story - Advantages over other ICFs cont.

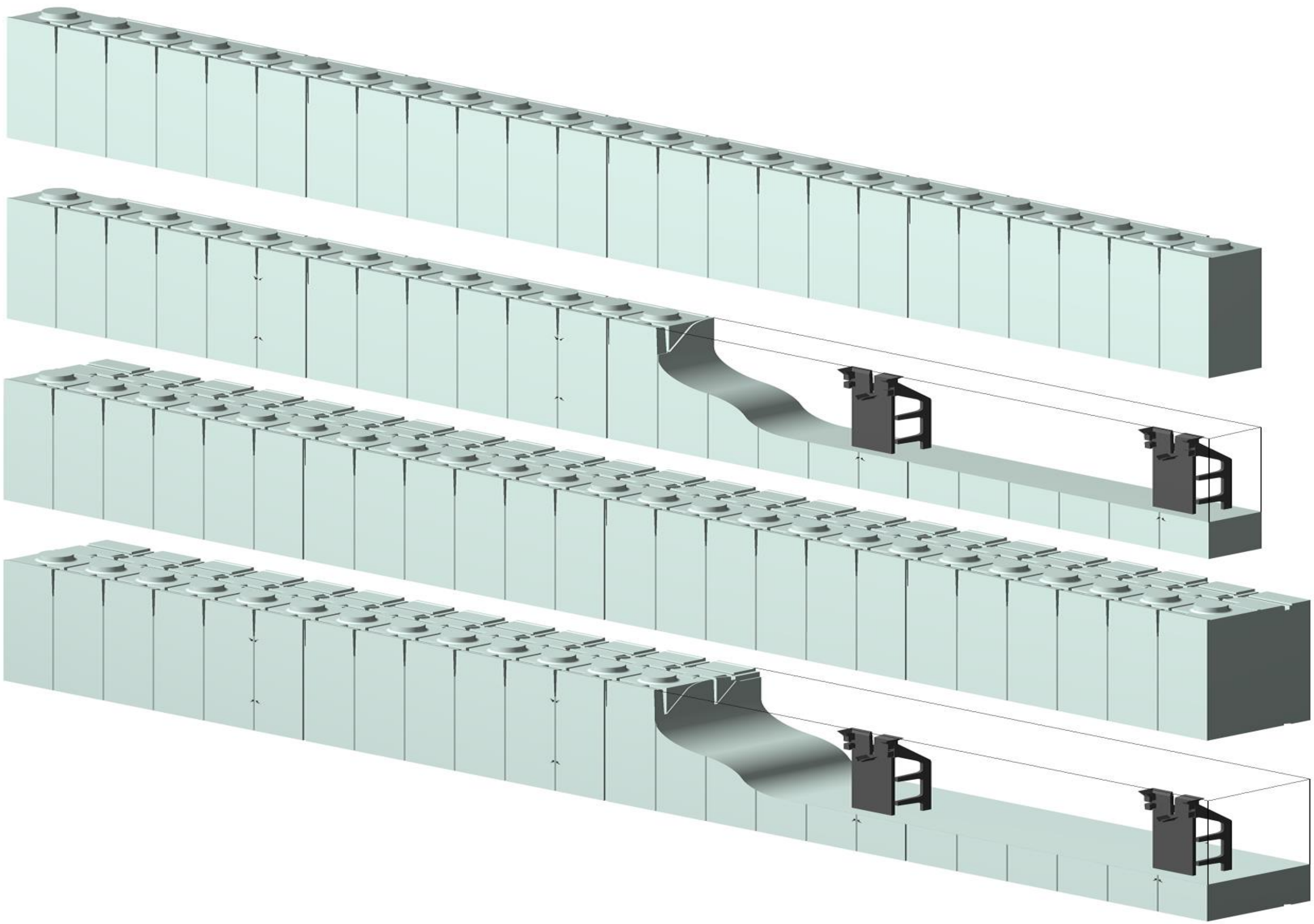
- No other ICF integrates concrete walls and concrete floors or roofs as well. Quad-Lock developed and tested unique solutions, such as Slab Brackets & Ties, and actively sells and supports an ICF for concrete floors & roofs, allowing lower freight costs by combining wall and floor shipments.
- Few other ICF companies offer access to a LEED AP (Accredited Professional) who can help designers identify & accrue LEED points for Quad-Lock projects.

Quad-Lock Green Roof Technology

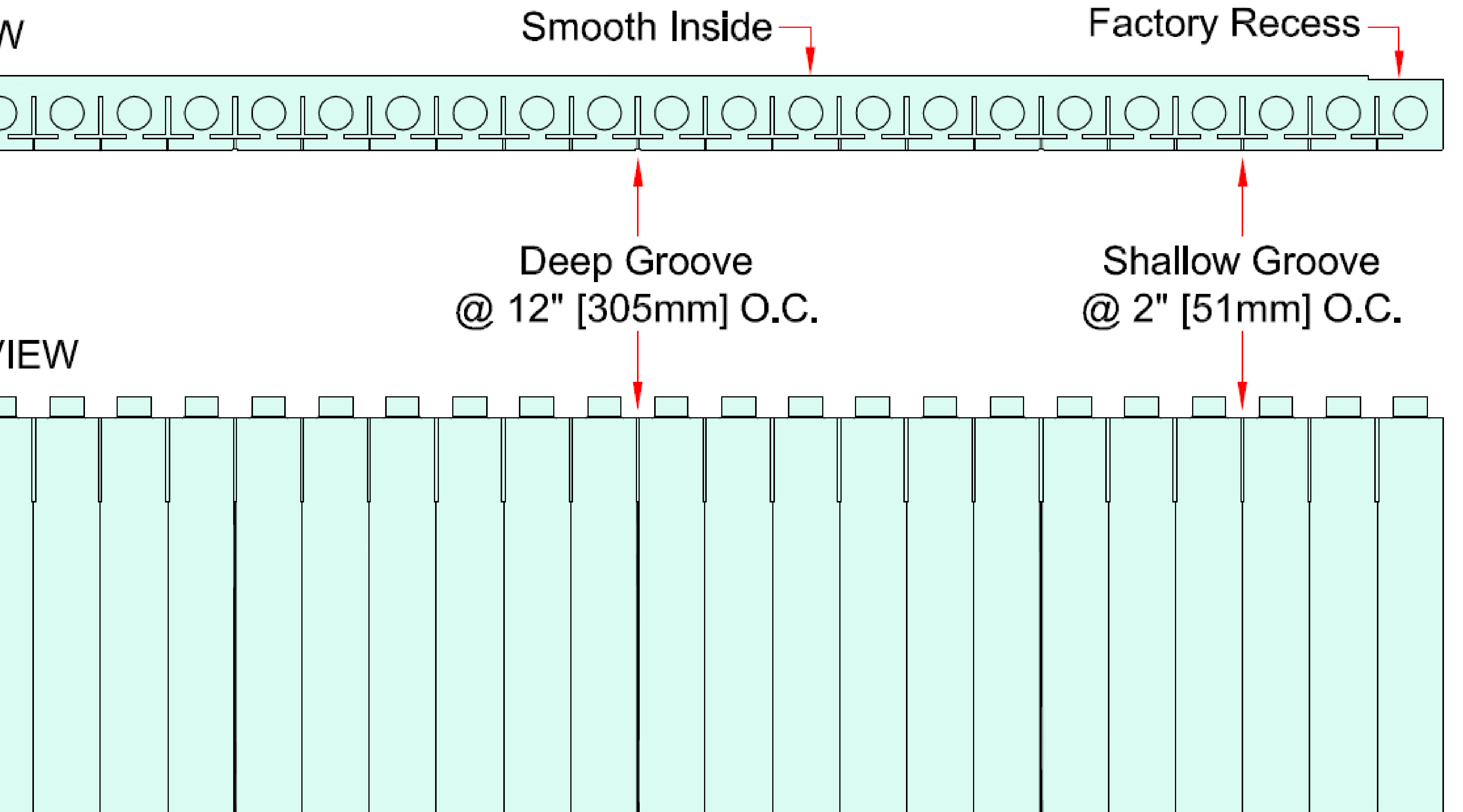
- Quad-Lock offers Green Roof technology with a rot-resistant roof structure that will carry the loads imposed by these designs. Learn more about Green Roofs.



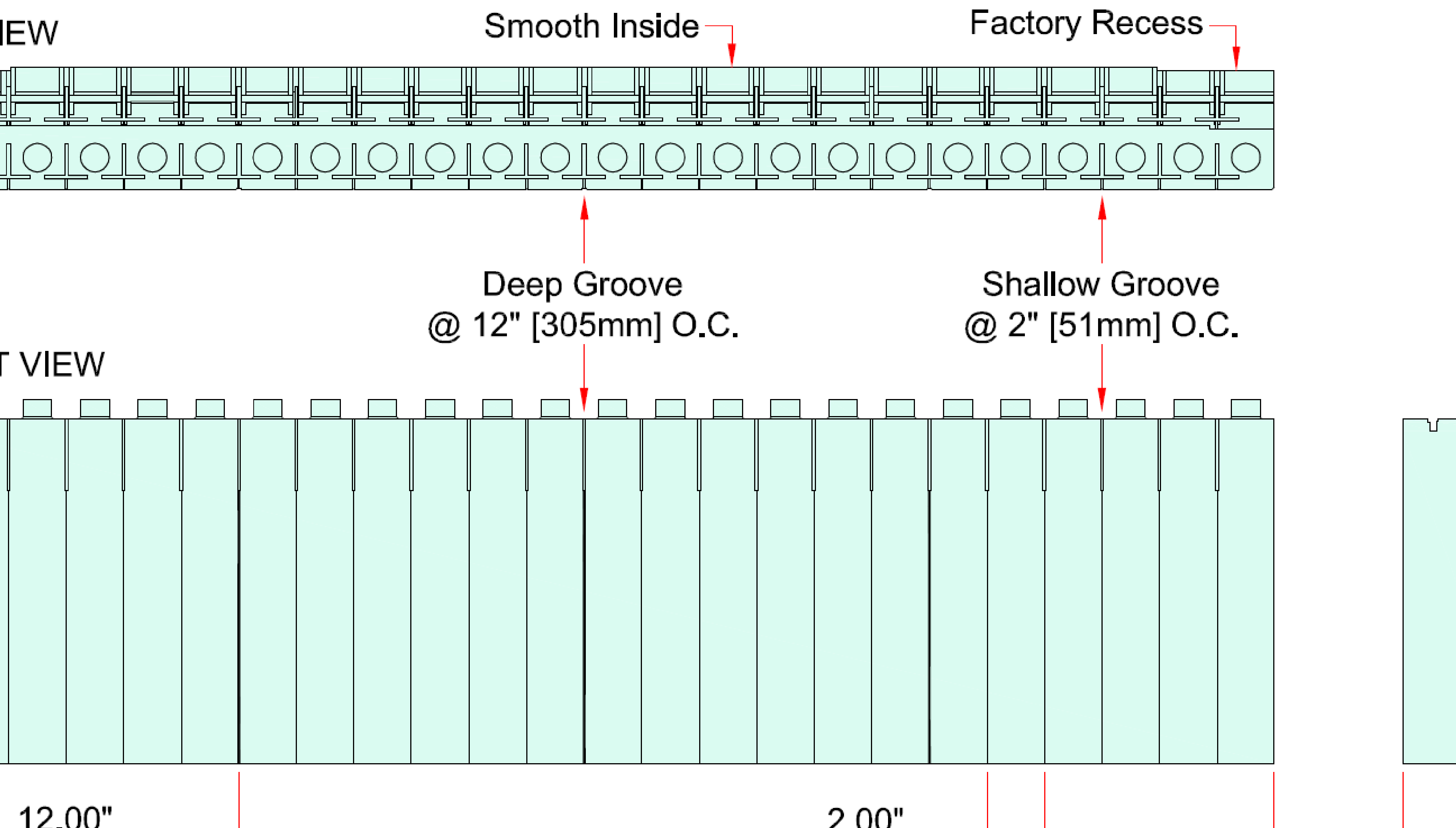
Quad-Lock ICF Wall Panel Design



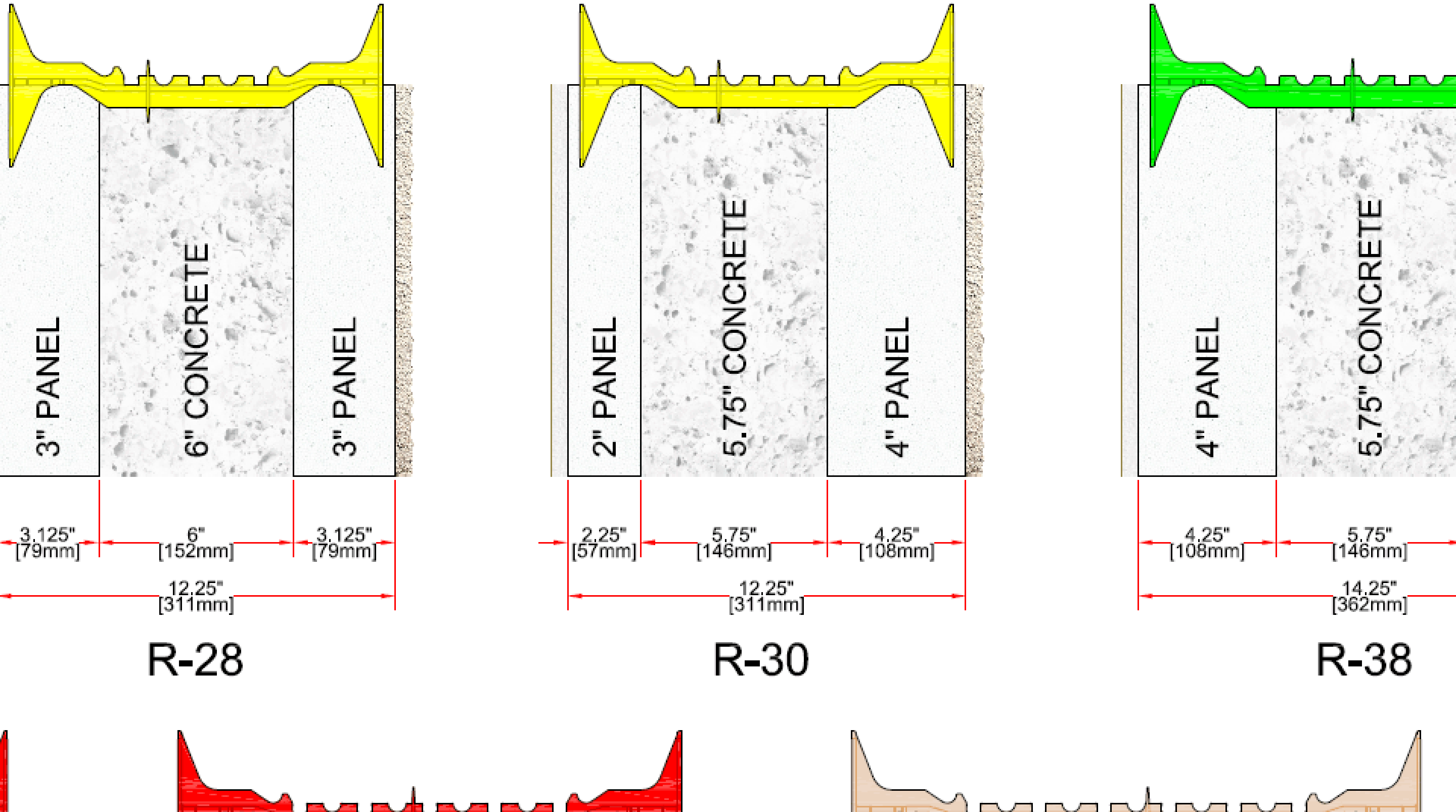
Quad-Lock Panel Dimensions



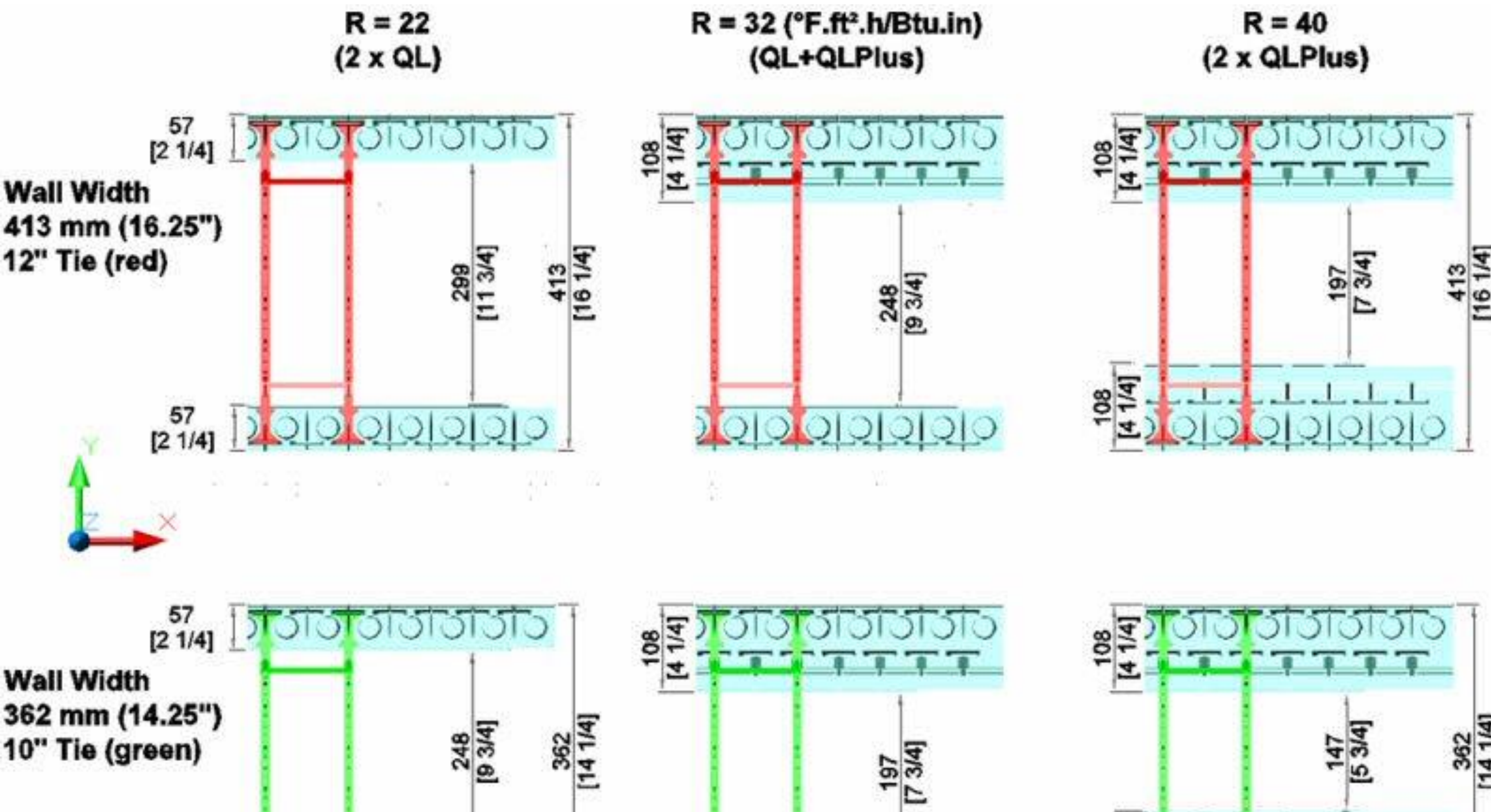
Quad-Lock Plus Panel Dimensions



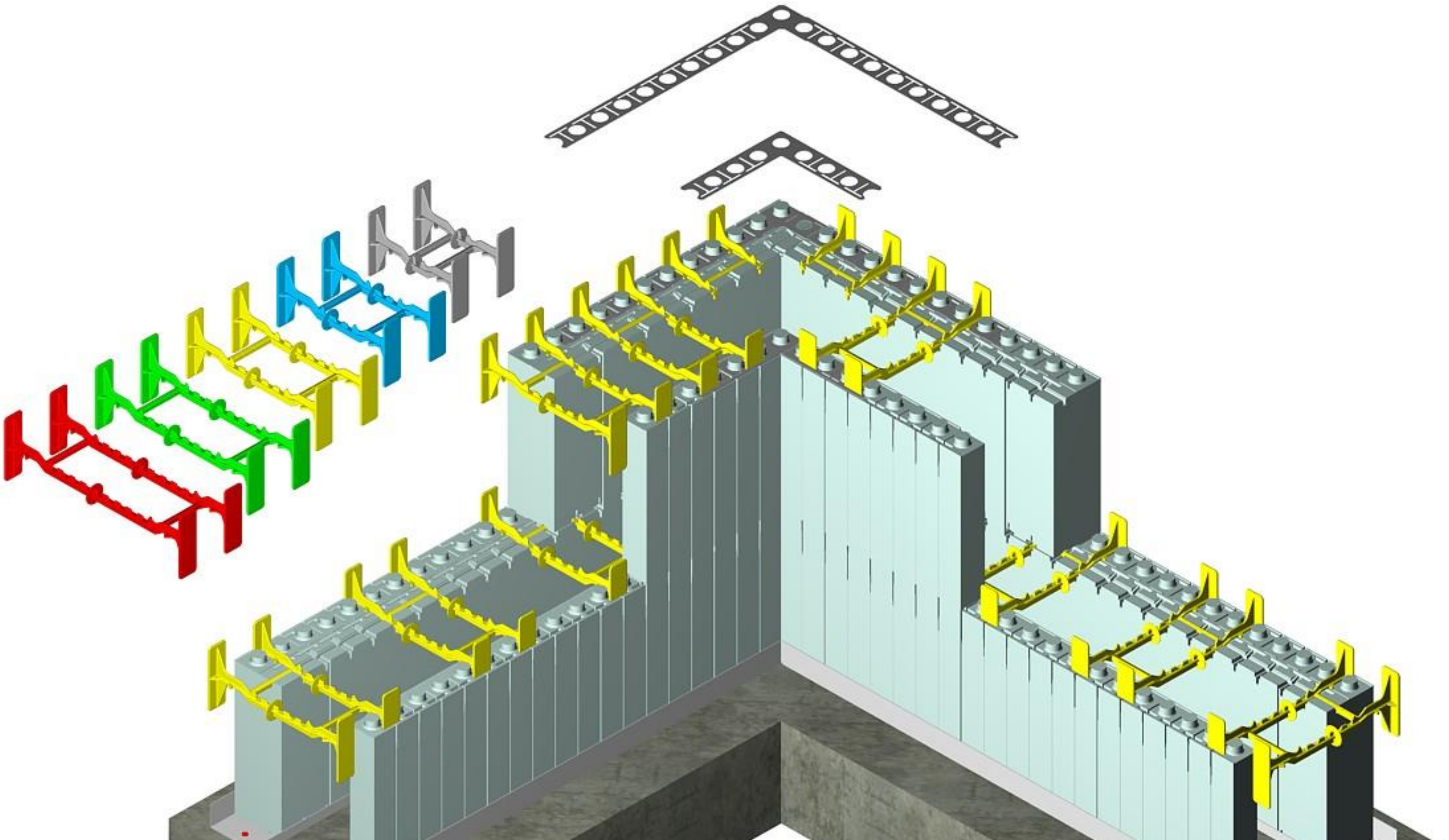
Quad-Lock Wall Panel Configurations & Dimensions



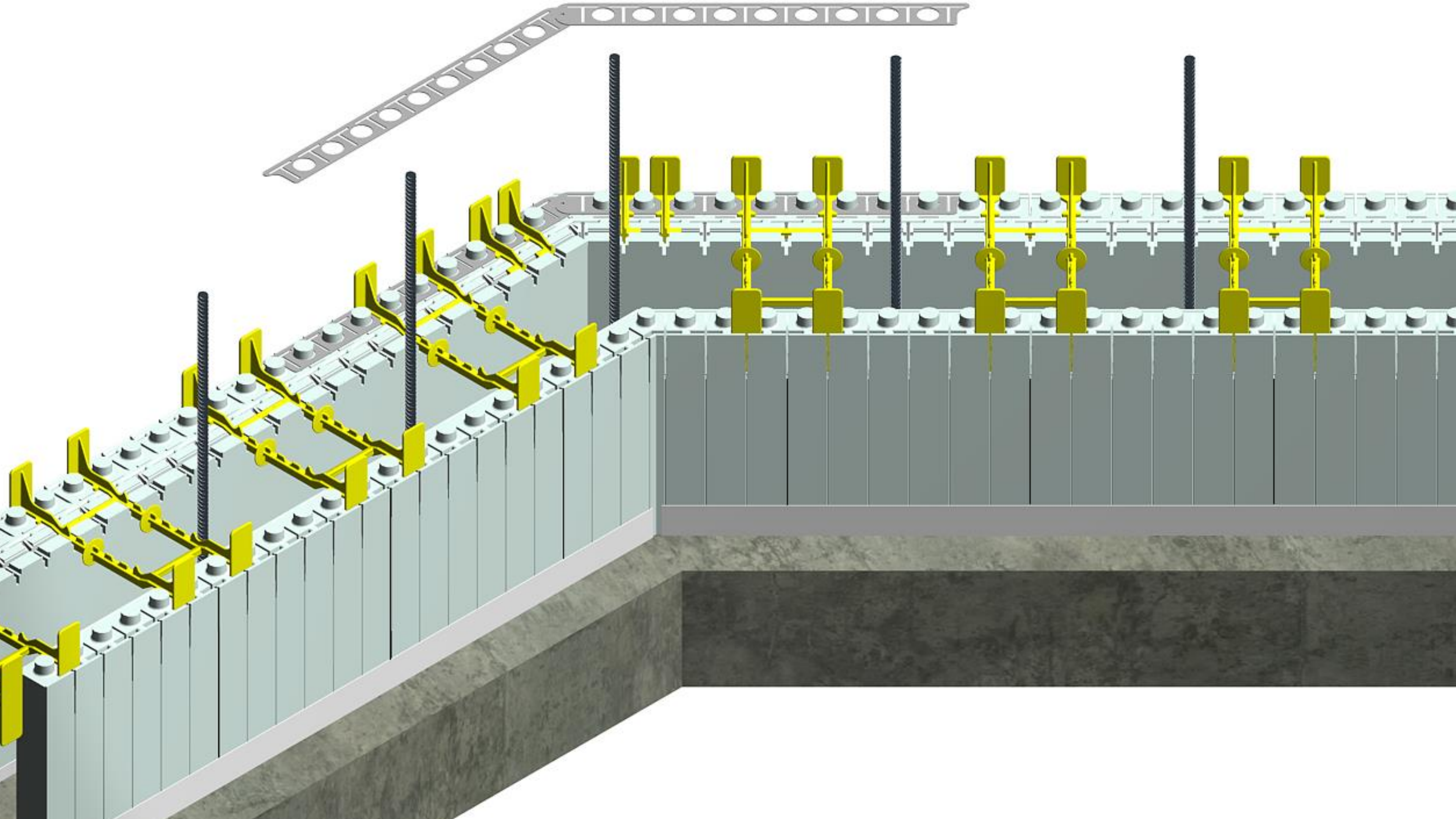
Additional Quad-Lock Configuration Data



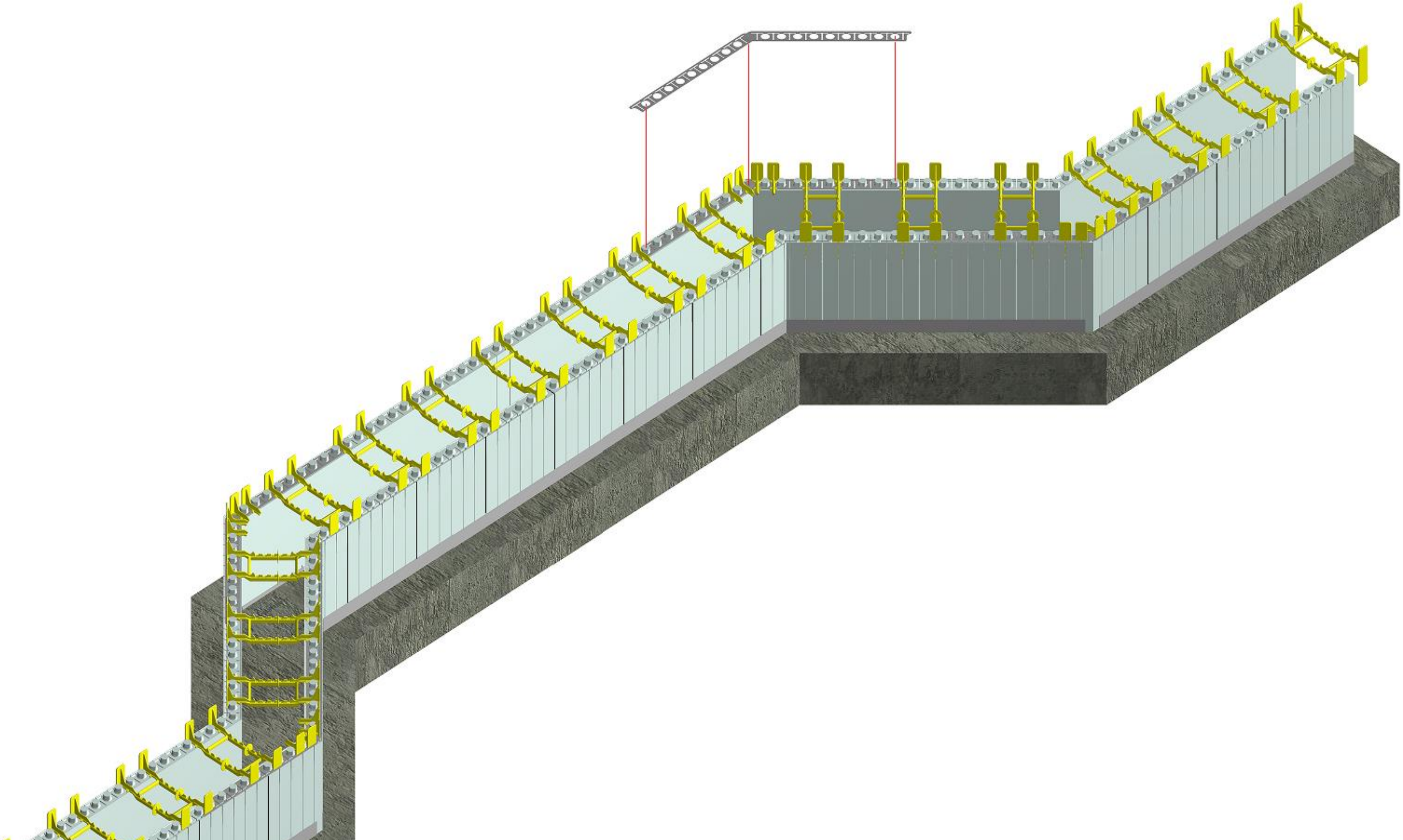
Quad-Lock Plus Corner



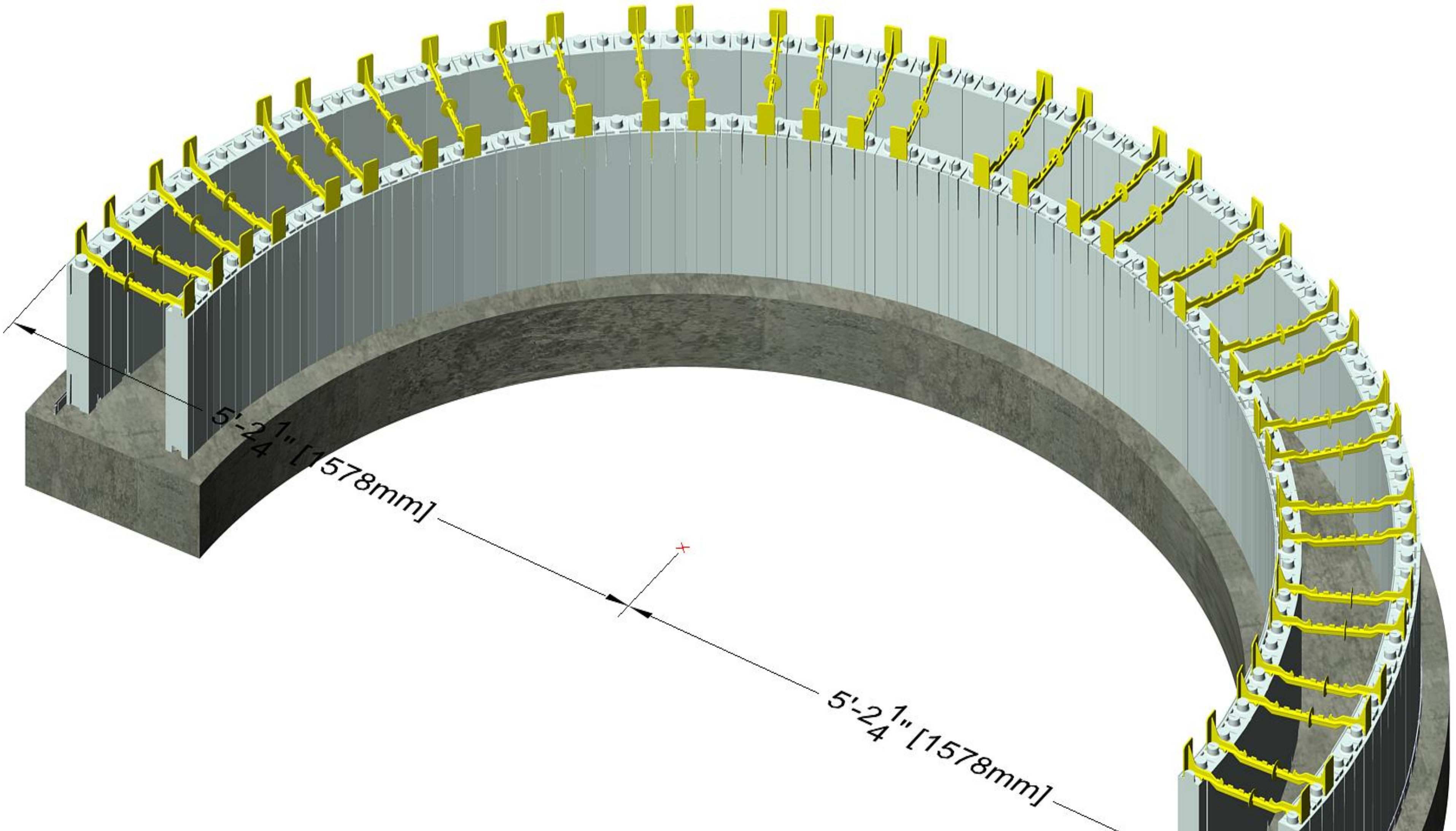
Quad-Lock Plus Angle



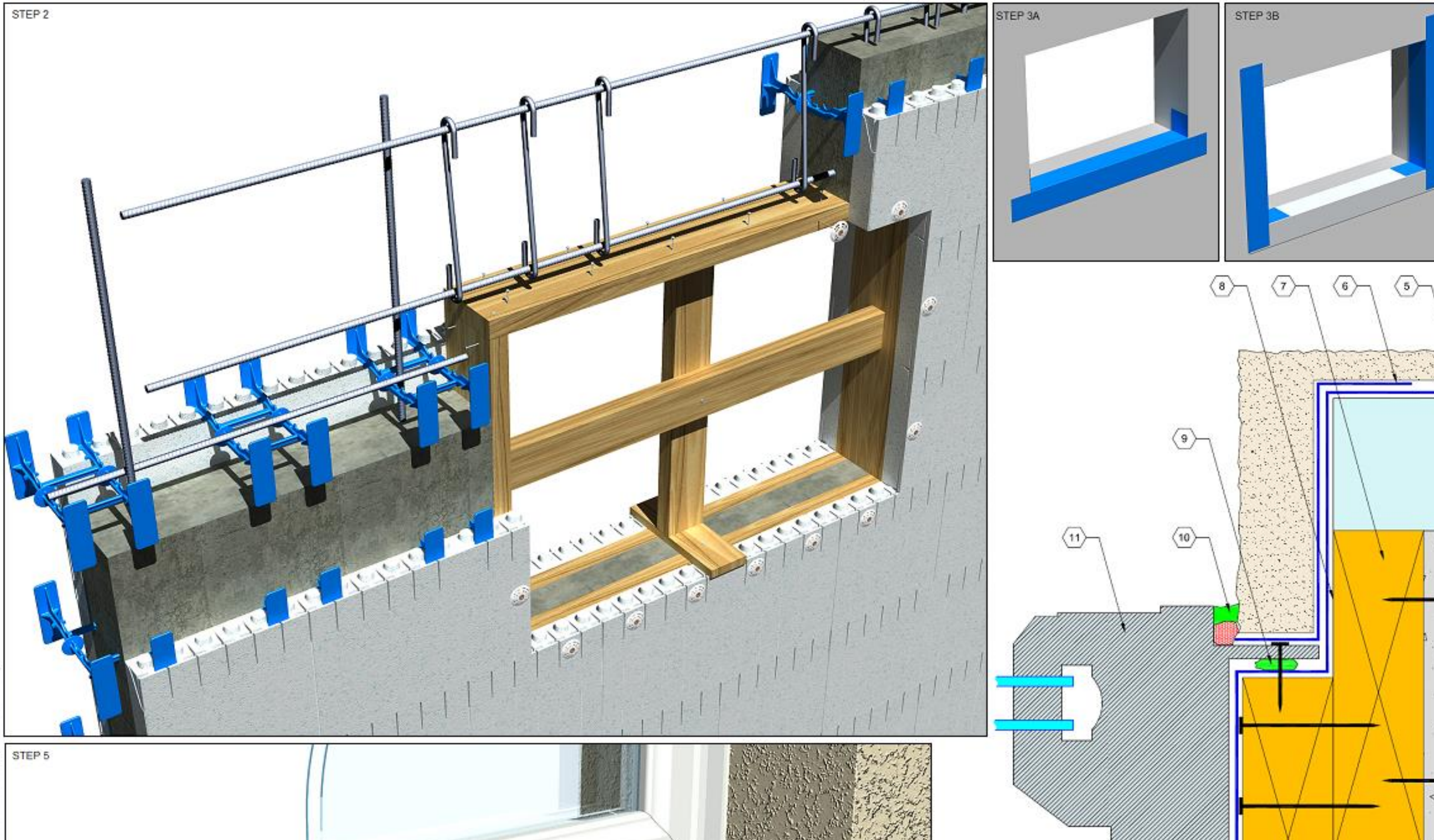
Quad-Lock Bay Window



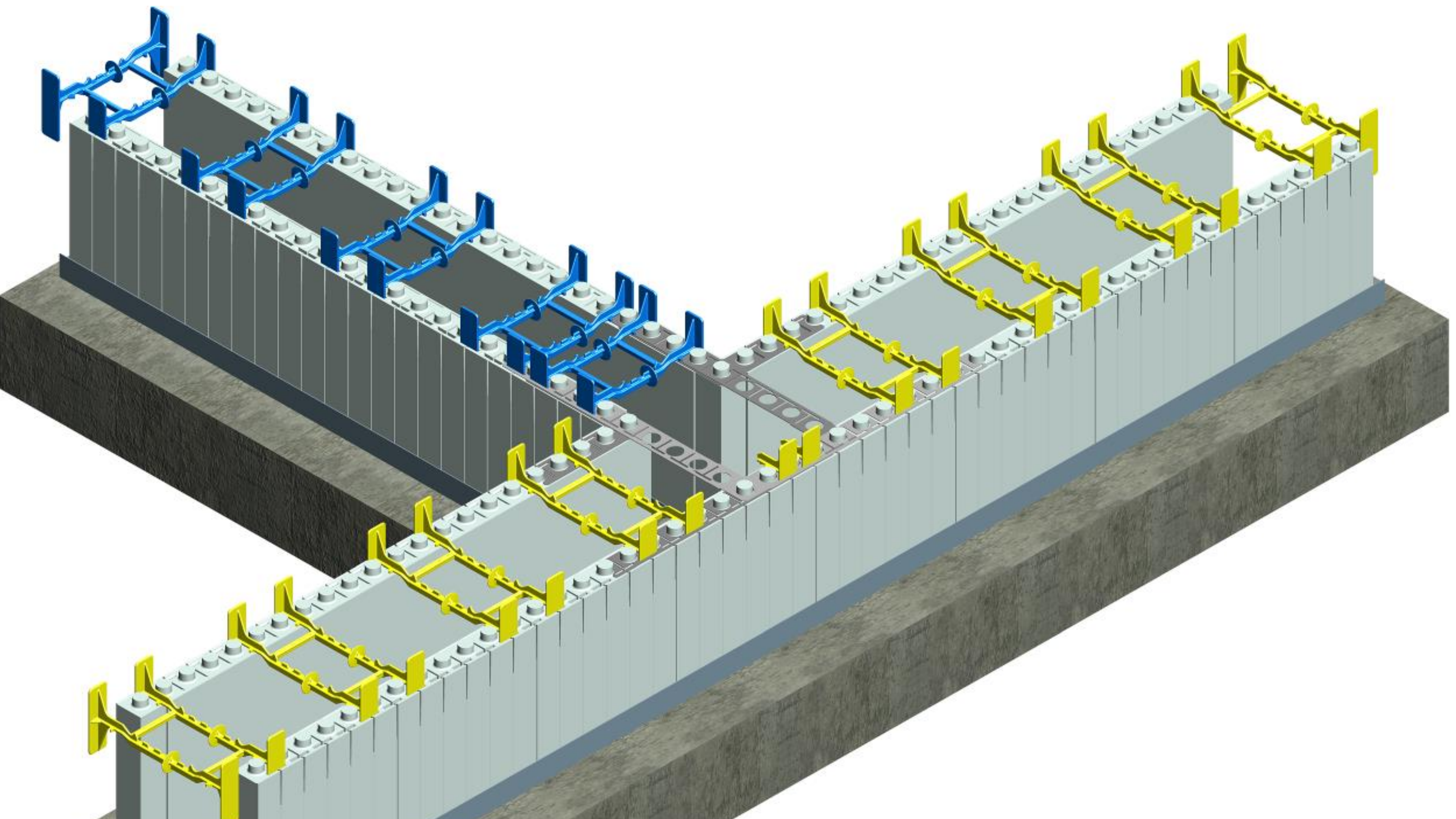
Quad-Lock Radius



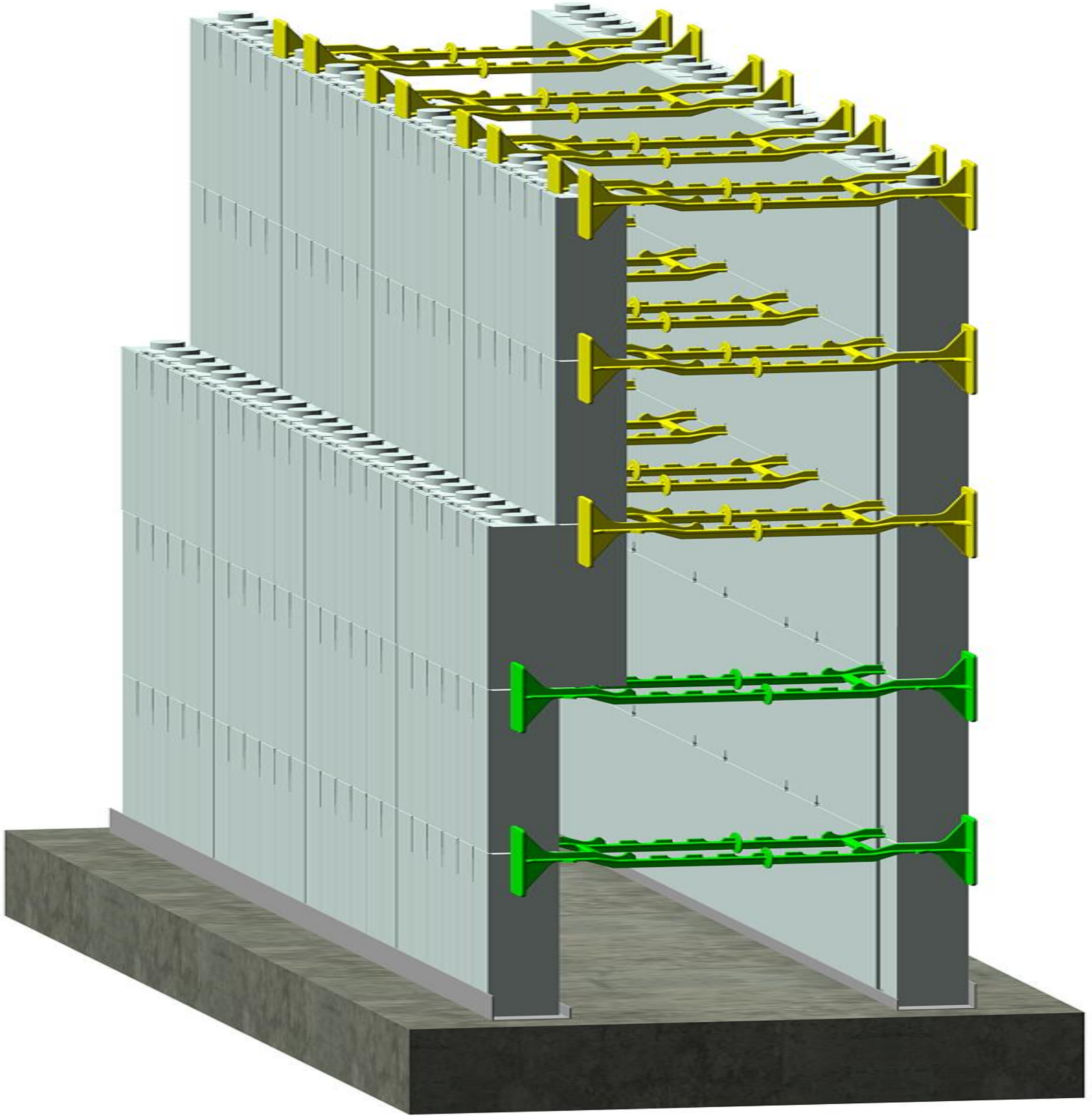
Quad-Lock Internal Window Buck



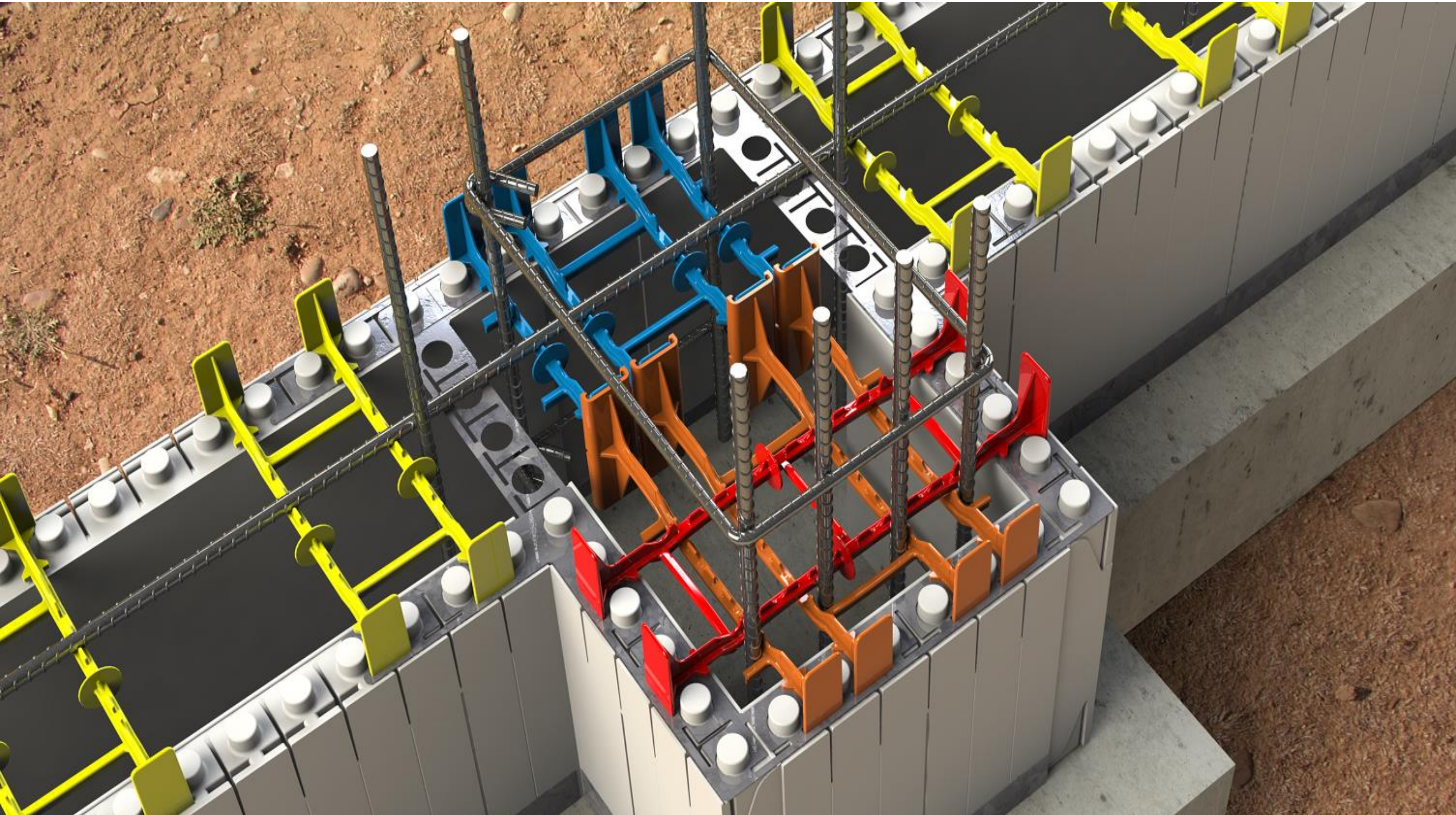
Quad-Lock T-Wall Connection



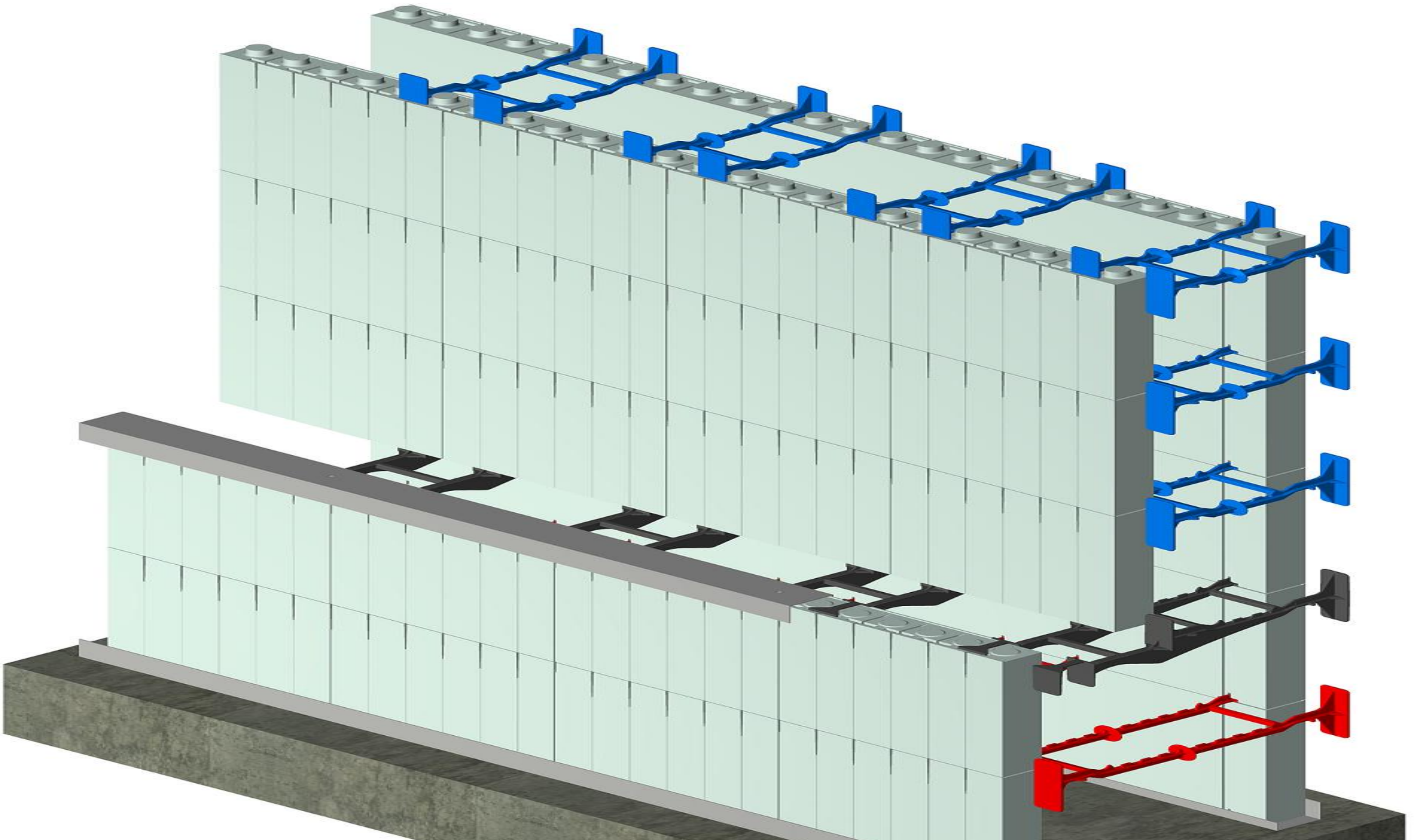
Quad-Lock Wall Width Transition



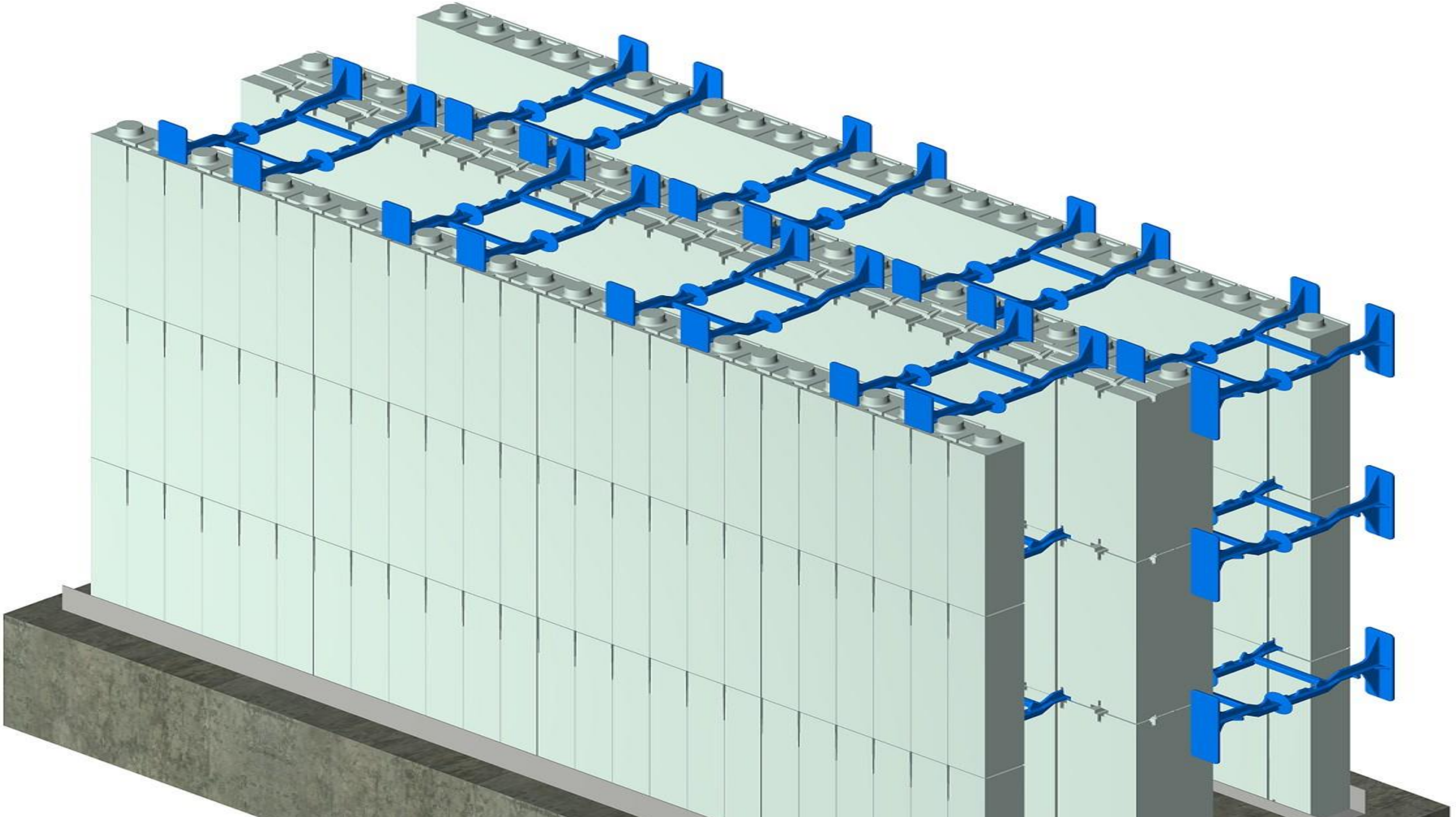
Quad-Lock Pilaster Configuration



Quad-Lock Brick/Masonry Ledge

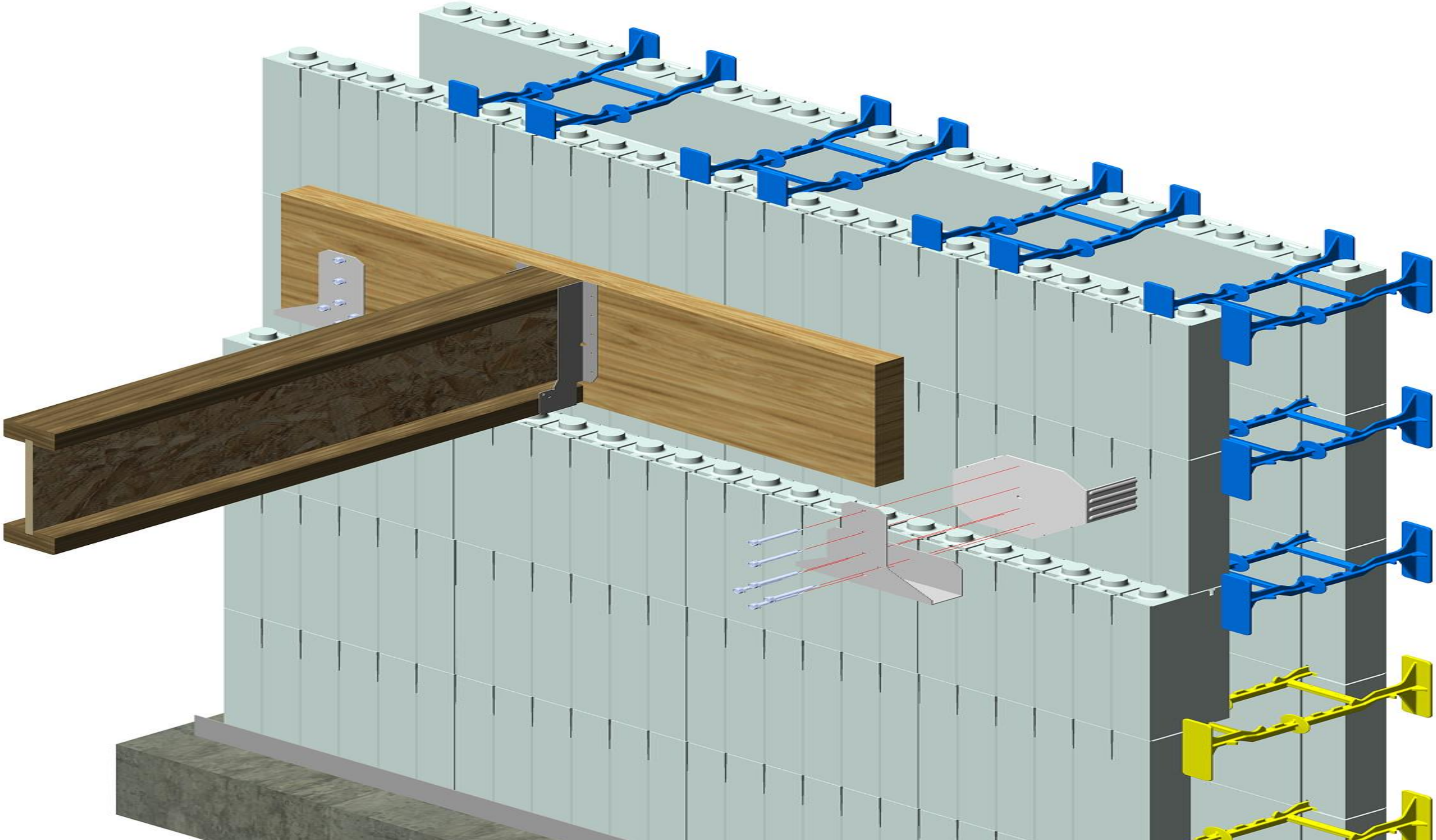


Quad-Lock Double/Common Wall

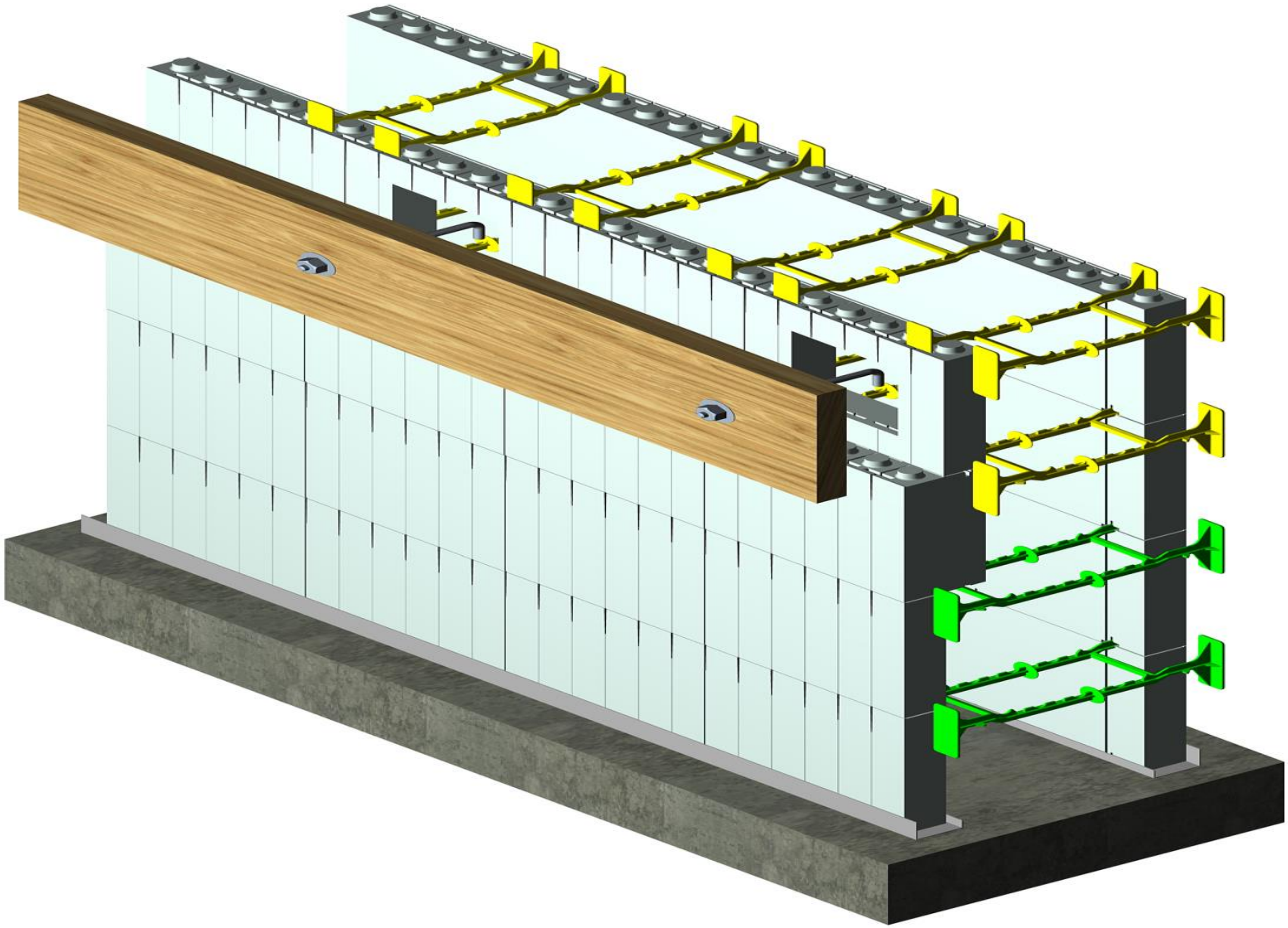


Quad-Lock Ledger Attachment

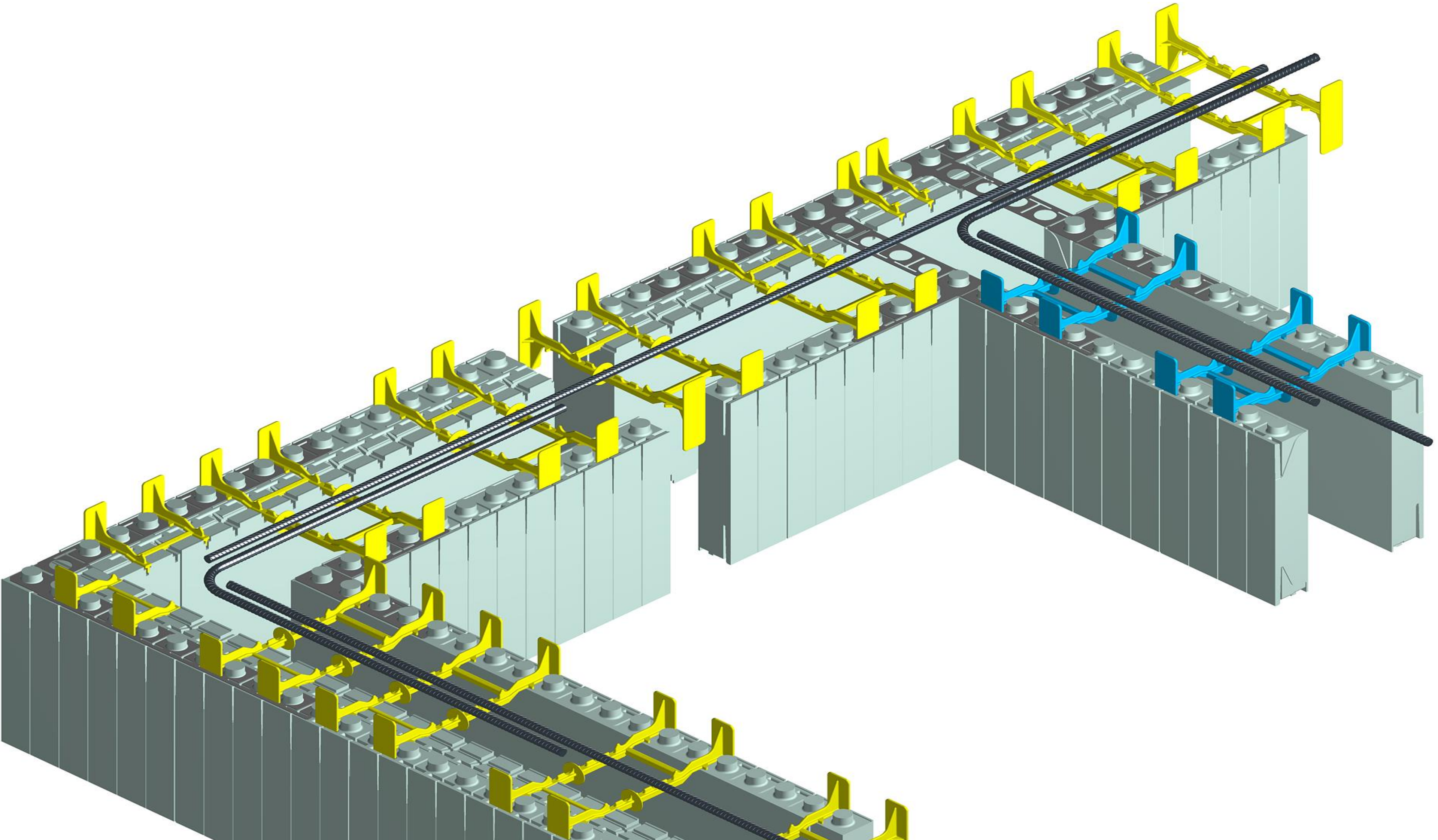
(Simpson ICF Ledger Connectors)



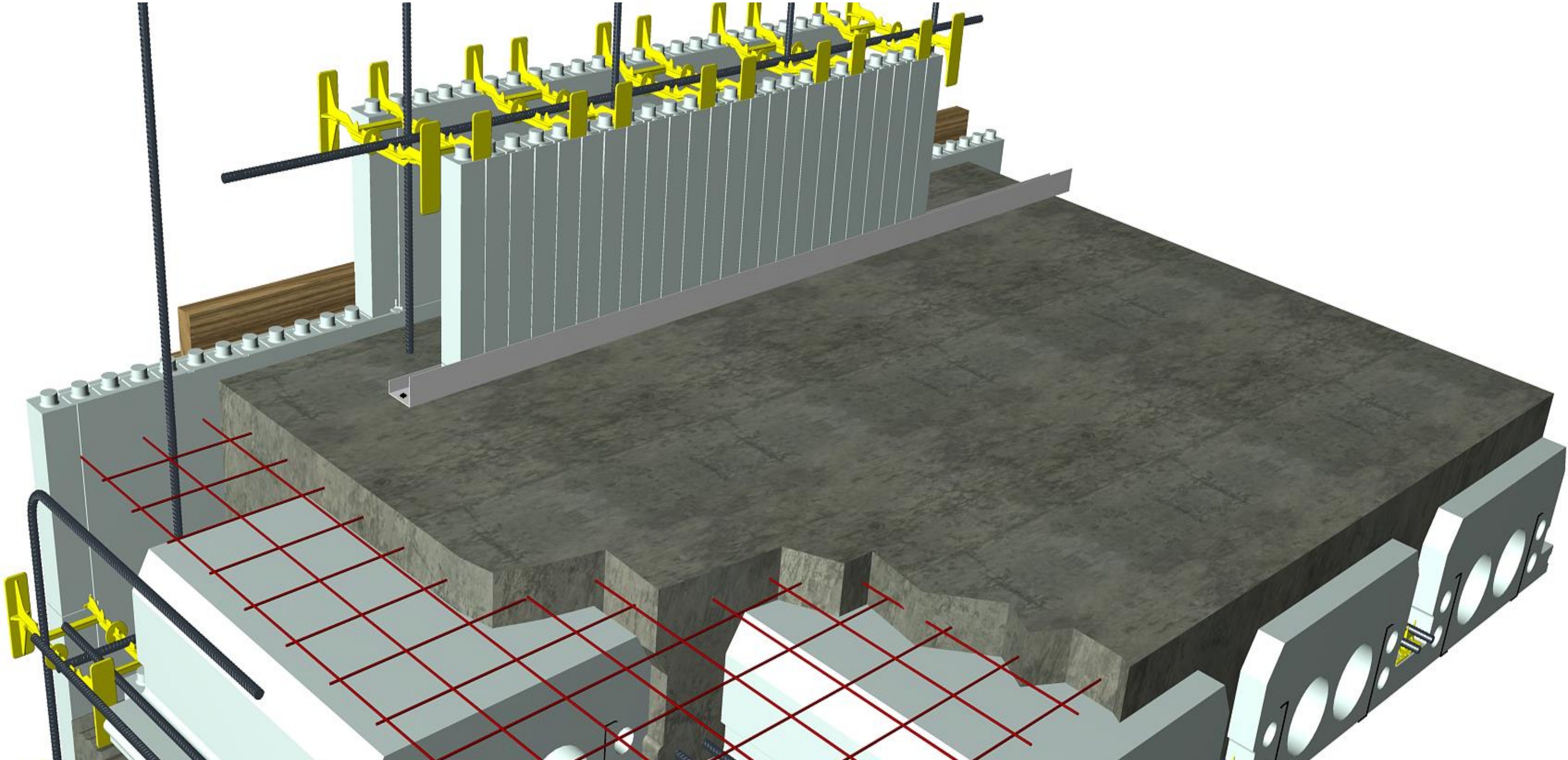
Quad-Lock Ledger Attachment
(Pre-Set Board with Bolts)



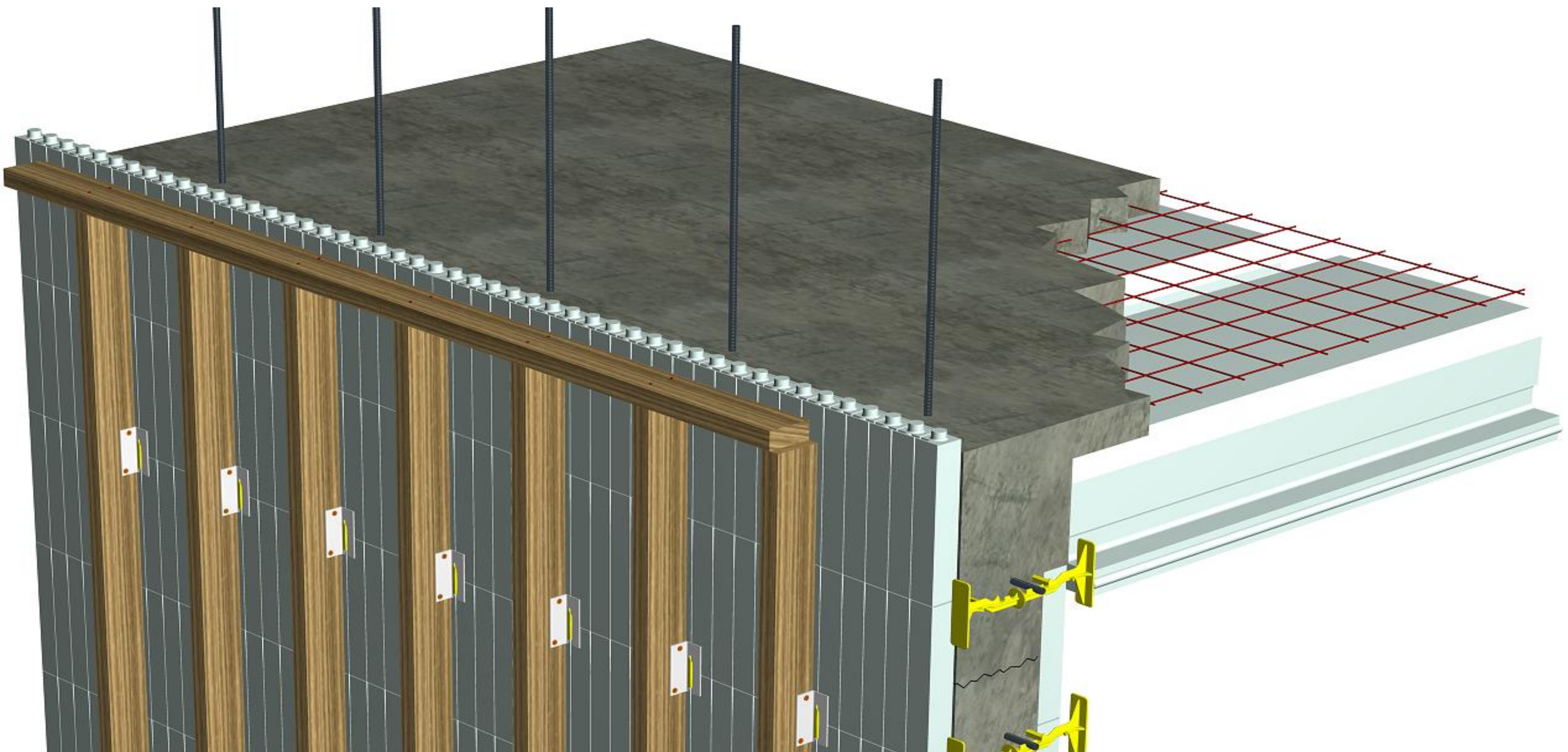
Quad-Lock Horizontal Rebar Placement



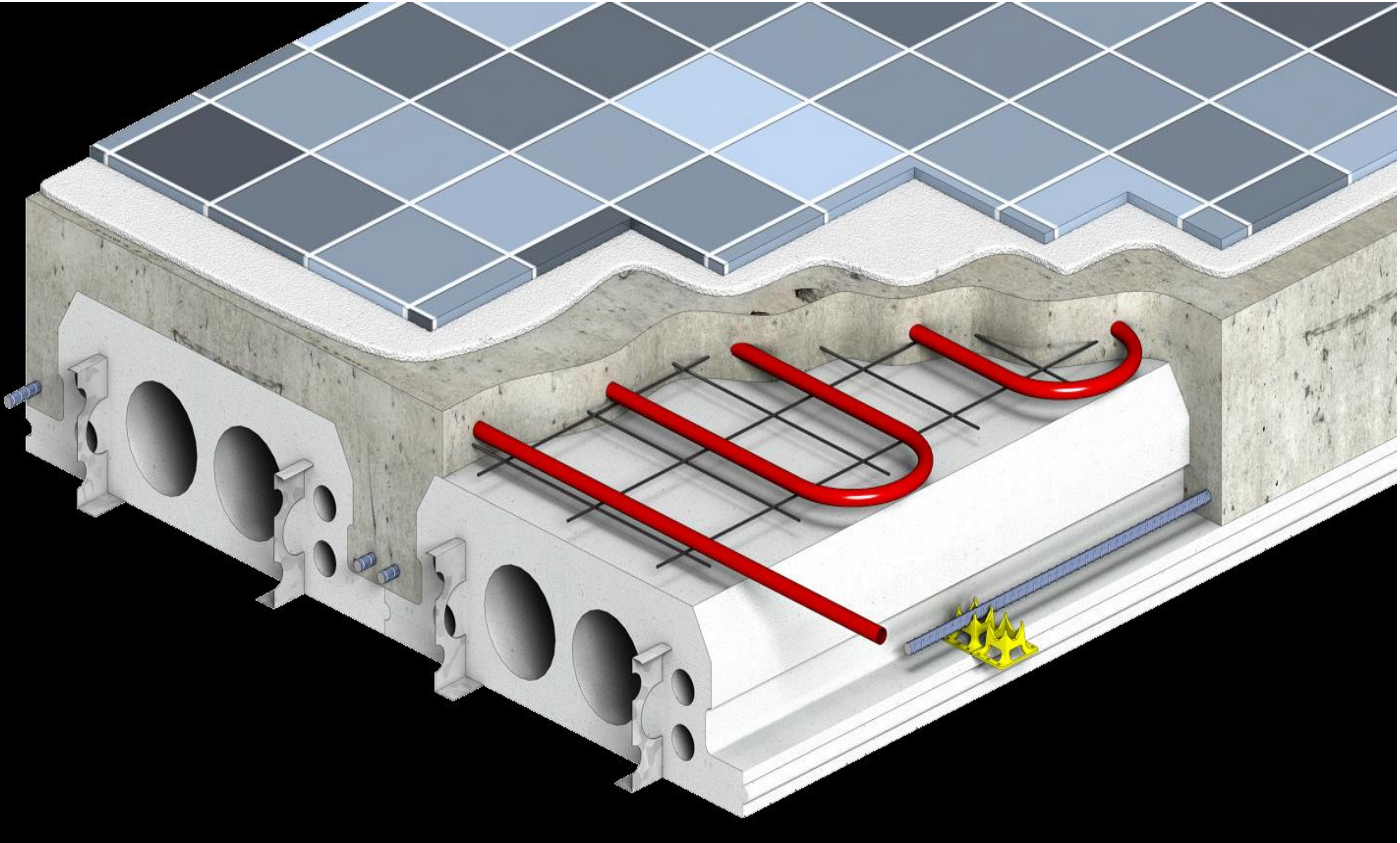
Quad-Lock to Quad Deck Connection & Slab Installation using Slab Ties



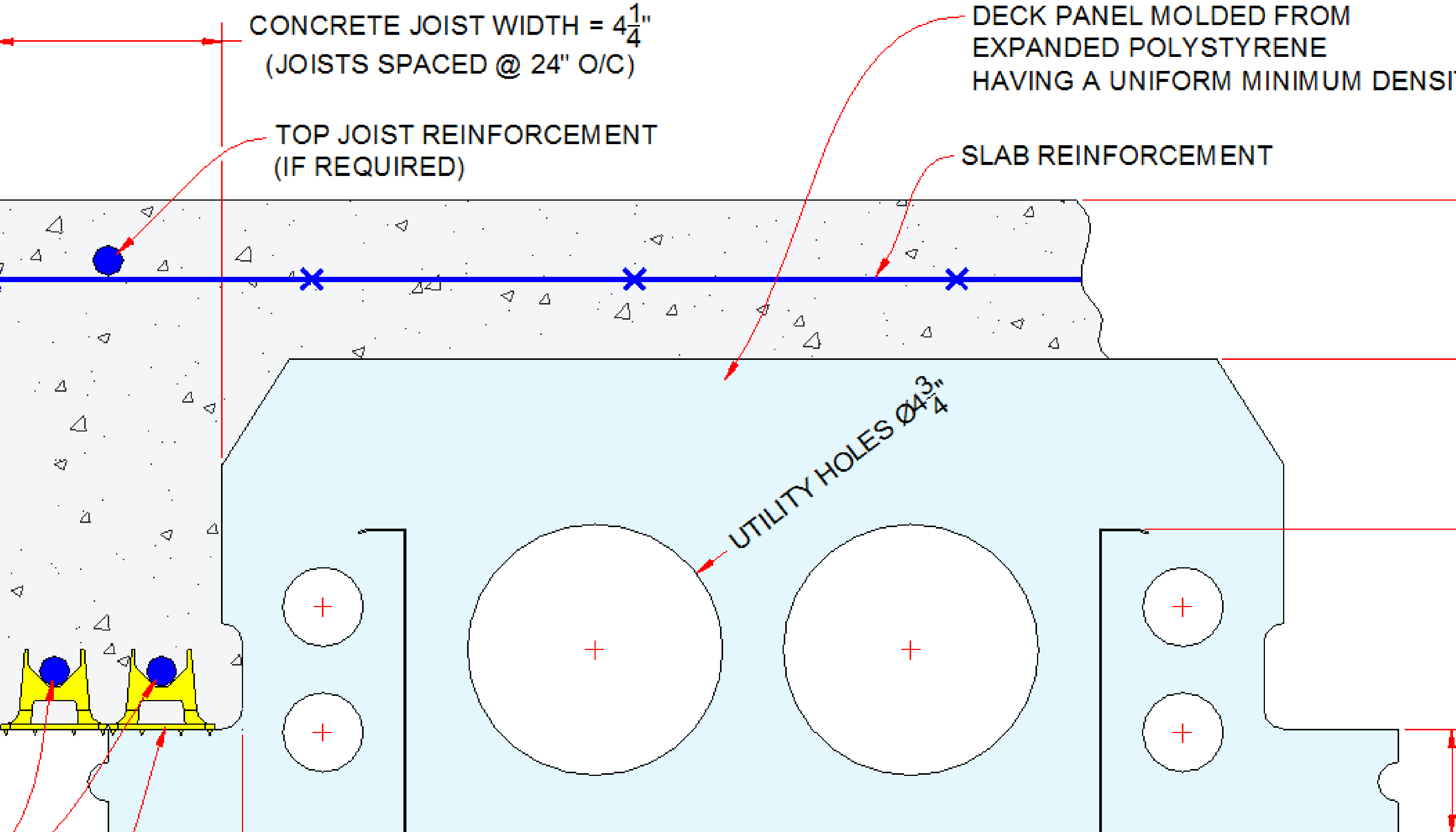
Quad-Lock to Quad Deck Connection & Slab Installation using Slab Ties



Quad-Deck Flooring & Ceiling



Quad-Deck Panel Dimensions



Integrated Metal Furring Joists

- 28 gauge steel Z strips contained in Quad-Lock panels provide structural strength and eliminate the need for secondary shoring members.
- 6-8’ spacing of primary shoring is required and will support workers, steel reinforcement, and concrete.
- Quad-Lock panels are constructed to building specifications and delivered onsite ready for assembly.

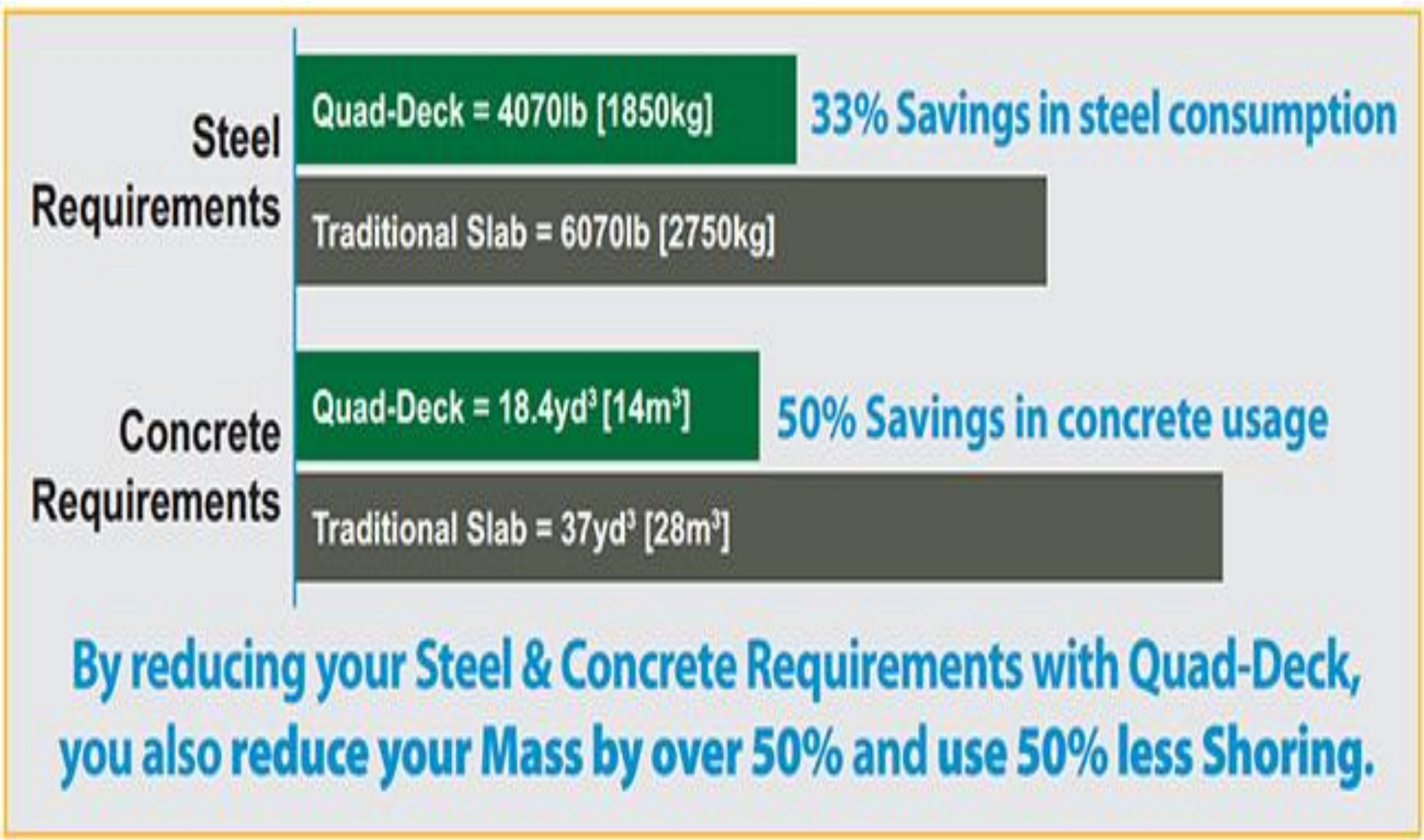
Quad-Deck Utility Holes

- Hollow cores in the Quad-Deck panels allow for running plumbing and electrical conduit/insulated wire through the ICF floor and ceiling structures using hot wire tools.
- The foam can be removed to install shared ducting for the ERV system and forced air cooling provided via integration with the geothermal heat pump.
- Quad-Deck panels allow for using up to 40% less concrete than full depth suspended slabs.

Interior ICF Bearing Walls

- The PHMH will include interior Quad-Lock walls for both the basement and main floor floors/ceiling structures which will limit need for shoring.
- Uniform sized logs and ICF block-outs will be utilized for supporting the Quad-Deck floor/ceiling structures and vaulted ceiling over the second floor during pouring/curing, and subsequently used for aesthetics.
- 9' walls will accommodate up to 12" lodge logs used for floor/ceiling support.

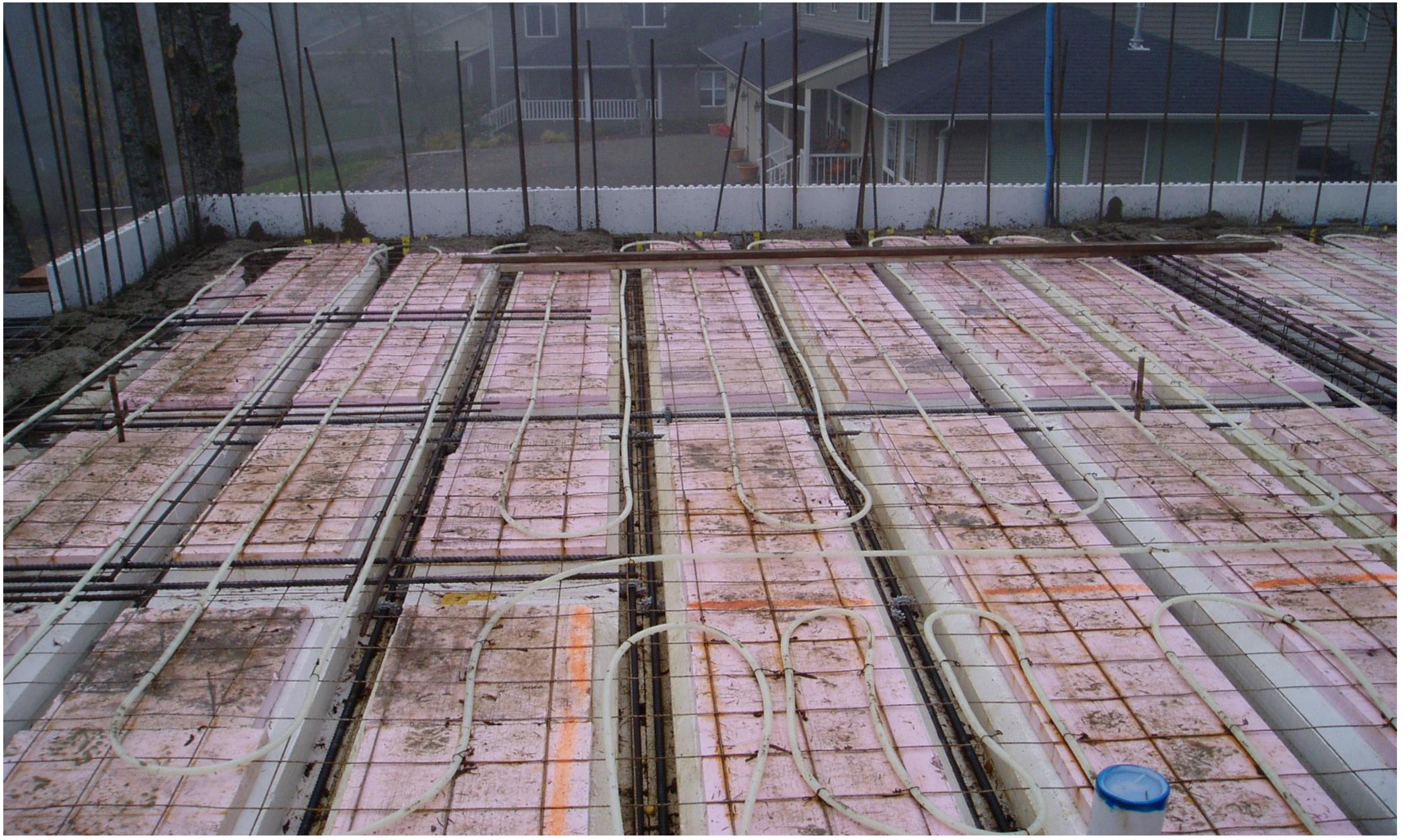
Quad-Deck Economics



Radiant Concrete Floor & Forced Air HVAC

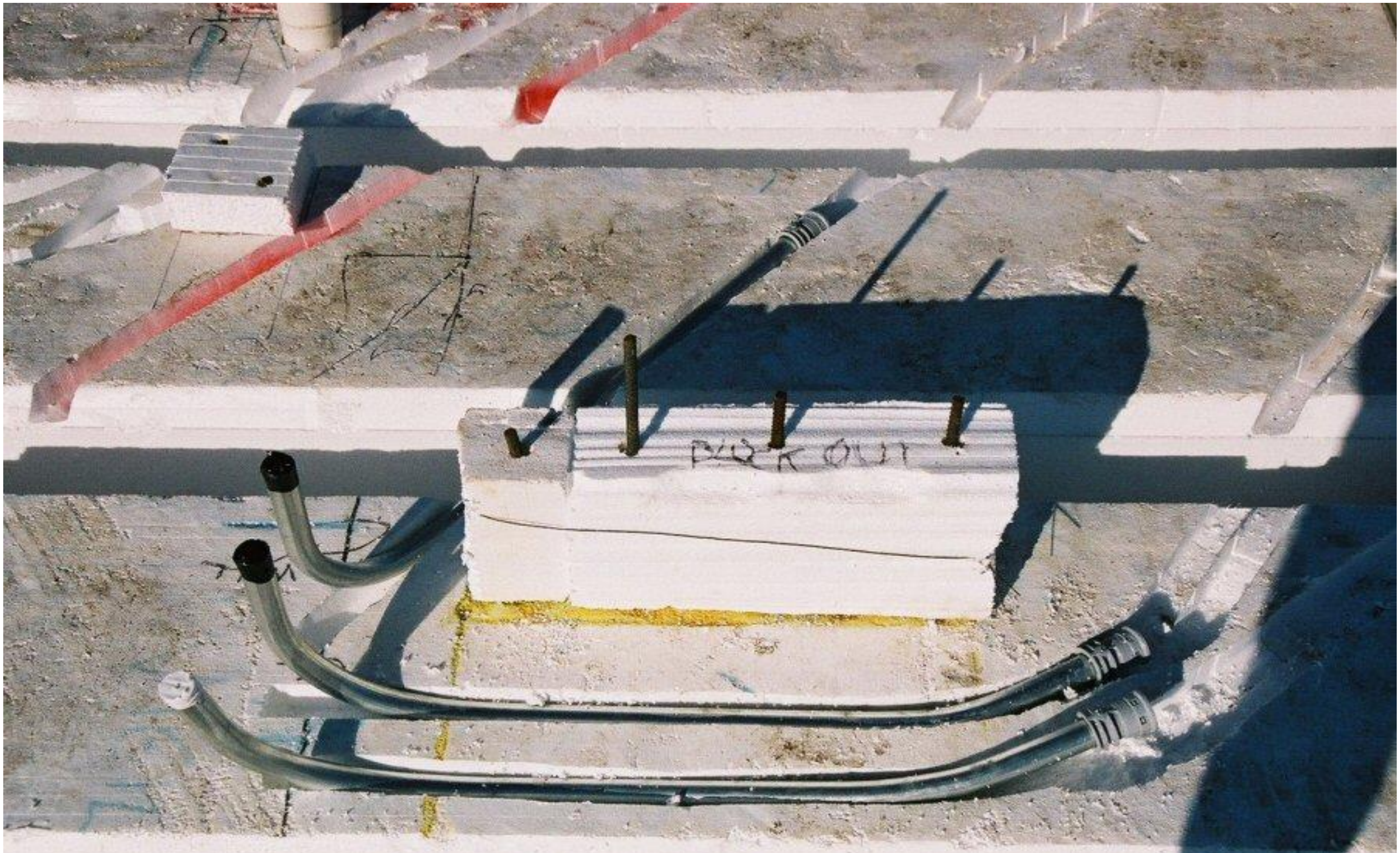
- Will be integrated with ICF and geothermal heat pump systems providing HVAC and hot water heating in the model home.
- Providing high efficiency radiant heating and cooling.
- ERVs coupled with heat pump coils may be used in addition to radiant technology to enhance air-flow and performance for the model home.

Radiant Heating & Cooling System inserted into ICF Quad-Deck Flooring



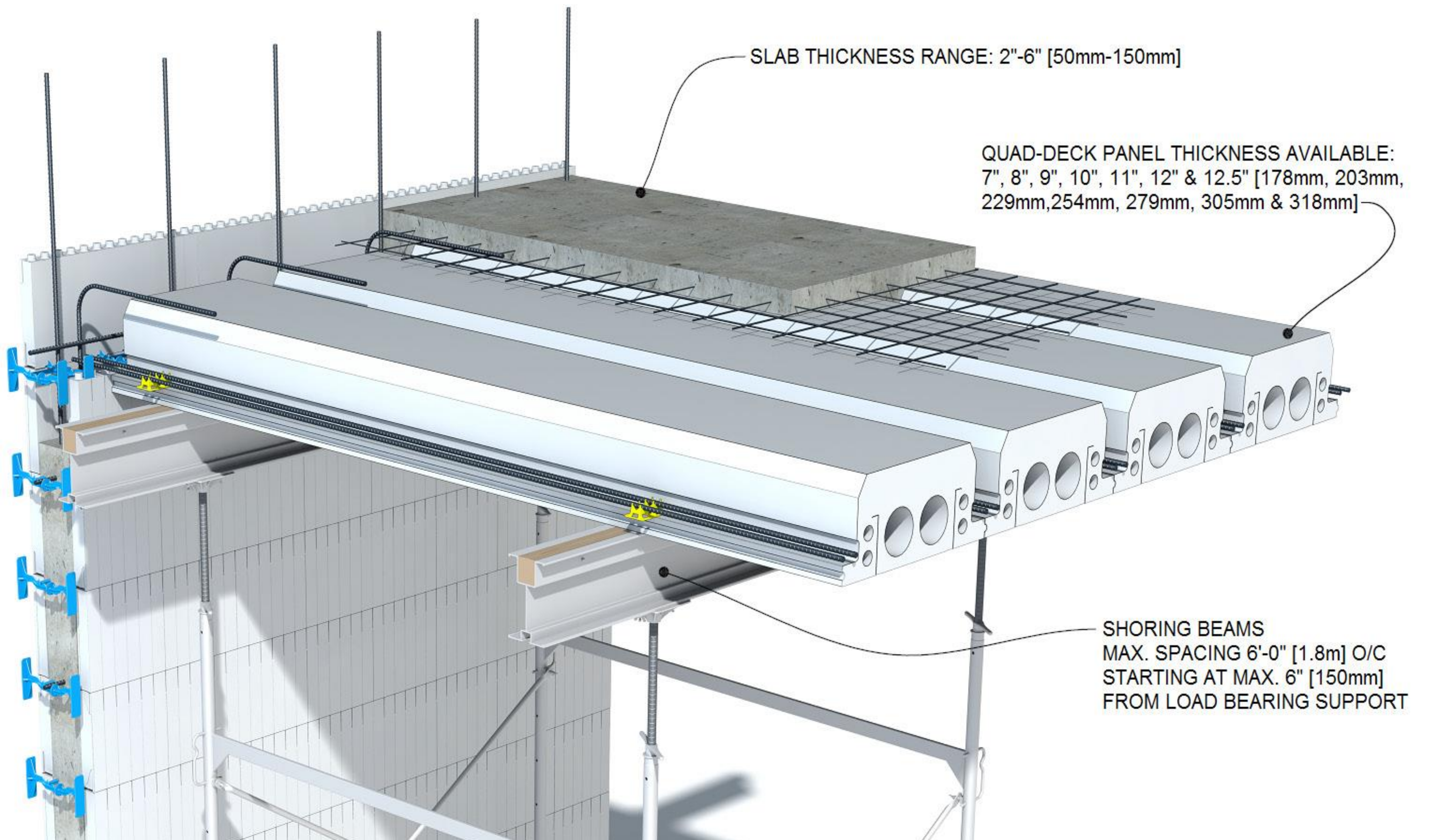
Radiant Heating & Cooling System Manifold to Geothermal Heat Pump

Electrical Conduit cut into Foam

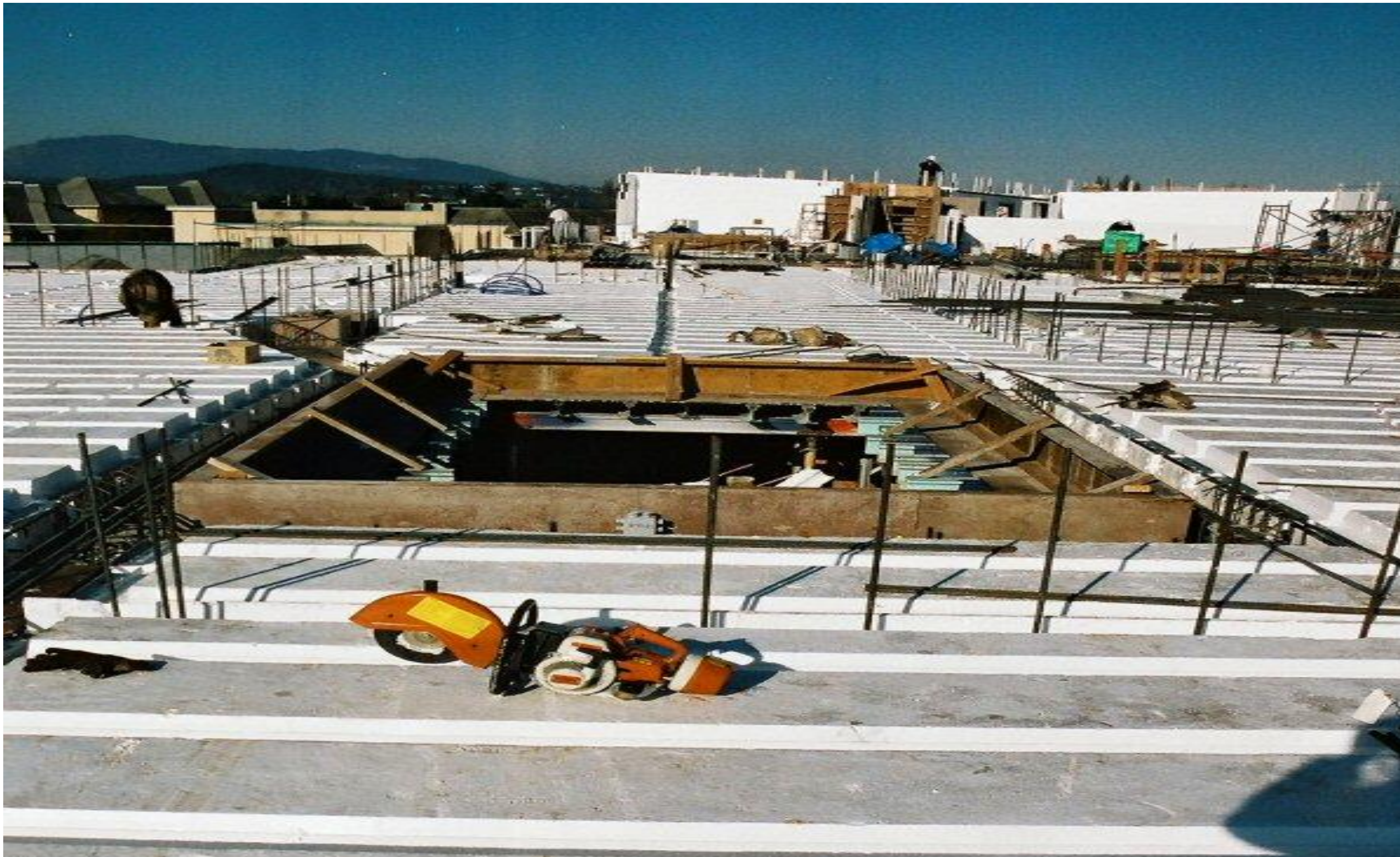


Plumbing cut into Dense Foam

Quad-Deck Ceiling Application



Quad-Deck Stair Opening



Pitched Roof for Vaulted Ceilings using Quad-Deck Panels

Pitched Roof Ready to Pour

Pitched Roof Pour Completed

Custom Manufacturing

- Quad-Deck panels are custom manufactured to size of spans according to building plans (4-sided hip roof, ridge beams NOT needed).
- The concrete roof will be covered with Foam-Control 16”x4’x8’ EPS (R-66) insulation plus ¾” OSB coverboard sheets glued and strapped to the concrete slab (covering the 8” R-16 ICF plus the 2-4” slab), providing a vaulted roof with a total insulation value of R-80 and no thermal bridging (27-29” thick vaulted roof).
- The roofing membrane will then be attached to the OSB coverboard.

Foam-Control EPS Boards

- 20 year warranted stable R-value: no thermal drift like XPS or ISO
- Unlimited fabrication available: Tapered and Coverboards
- Variety of density, thickness, and size
- Meets ASTM C578
- Building code recognized
- UL QA monitored, tested, certified, listed
- FM Approved
- Single-Ply, MOD-BIT, and BUR compatible

Advantages of Quad-Deck

- Quiet, Healthy, Safe & Comfortable
- More consistent indoor temperatures
- Perfect for in-floor radiant heating
- High STC ratings; deadens sound transmission
- Minimized air infiltration - fewer allergens, improved indoor air quality
- Inert materials: doesn’t support the growth of mold or mildew
- Rated Fire Resistance (using ACI 216.1)
- Not a food source for insects
- Superior protection against disasters

Durable & Sustainable

- High R_{ip}-Values (R-16 to R-33.5); Low U_{si}-Values (0.35 to 0.17)
- Reduced HVAC requirements, heating and cooling costs
- Thermal mass properties; ideal for passive solar designs
- Lower life-cycle costs
- Long-term building durability; life-cycle measured in centuries

Fast & Flexible

- Lightweight, easy to handle - no forms to be stripped
- Delivered to site ready to install - pre-cut at factory to exact specifications
- Self-reinforced forms - temporary shoring only every 6'
- Available in thicknesses of 7" to 12½", up to 34' [10.3m] free spans (and more with additional EPS caps or post-tensioning)
- Slab thickness from 1¾" to 6" [45mm to 152mm]
- Easily integrates with Quad-Lock ICF system

Lightweight

- Lighter structure; eliminates 50% of conventional shoring
- Reduces floor mass dead load by up to 50%
- Reduces structural requirements for foundations and walls

Reduced Costs

- No site waste
- Uses less concrete & steel compared to traditional concrete slab
- Lower workers-comp due to lightweight forms

Quad-Lock to Quad-Deck Connection

Quad-Lock to Quad-Deck Connection cont.

Quad-Deck Crossbeam

Quad-Deck Pour

Quad-Lock & Quad-Deck Installed

Stronger Concrete Structures

- Water does not evaporate as quickly from Quad-Lock in comparison with other ICF systems.
- This higher moisture content during curing results in a 50-70% increase in compressive strength (e.g., 5,700 lb/in^2 vs. 3,600 lb/in^2 for conventional plywood concrete forms).
- Removal of bracing can occur about 48-72 hours after pour.
- 80% curing is required before backfilling.

Fly Ash & Blast Slag

- Relatively high percentages of fly ash and blast slag will be utilized for substituting cement in Quad-Lock ICF.
- Addition of these substances will affect slump, cure time, and initial compressive strength and thus will be taken into account.
- Use of Pozzolans to concrete mix generally makes the mix more flowable which is advantageous for ICF construction. However, this may affect the dosage of plasticizers or other agents used to improve flow characteristics and care must be taken not to exceed recommended 6” slump.
- Engineers will take this into consideration.

Cold Weather Pouring

- Quad-Lock Plus panels allow for pouring with temperatures as low as -75° F.
- This is achieved by placing concrete and maintaining surface temperature at 50° F for 3 days.
- This is possible due to increasing EPS insulation (R-59 Quad-Lock Plus panels) and by increasing cement content to 600 lb/yd^3.

Cold Weather Curing

- Concrete must arrive at the site sufficiently warm to be placed at or above certain minimum temperatures according to Quad-Lock ICF configuration and cement content.
- Air entrainment should be included in the mix design if concrete is being exposed to freezing temperatures. Under these conditions, the insulating qualities of the Quad-Lock panels should sufficiently insulate the concrete long enough for the curing process to complete.
- Tops of walls should be covered with insulation immediately after pouring.

Recessed Lighting

- The recessed cans will be cut into the concrete floor/ceiling ICF structures and conduit will be run before or after pouring concrete.
- We will utilize low heat/low energy LED bulbs.

Low Voltage Boxes & Conduit

- Wall outlets and wiring for telephone, Internet, home music/theatre, home security, and TV cables will be inserted into the ICF prior to pour.
- In accordance with building codes, these low voltage wires and cables will be run in separate conduit and run perpendicular to high voltage conduit in order to avoid electrical interference.

Sheetrock, Flooring & Siding Alternatives

- Aesthetic tongue and groove pine can be used as a cost effective alternative to sheetrock for ceiling and wall coverings, particularly in conjunction with using aesthetic lodge logs (10-12” in diameter), pine beams, or glue laminates in place of conventional shoring.
- Material costs for decking and paneling can be less than drywall, e.g., as little as $16 per 4x8 area using 1x6 or 1x8 tongue and groove pine or fir with less labor required for the finished look (no taping, mudding, or texturing).
- Similar products can also be used for flooring and siding.

Pine Tongue & Groove Ceiling

These beams would be replaced with lodge logs that run perpendicular to Quad-Deck panels in the loft/2nd story of the PHMH (replacing inefficient attic space with value added living space).

Elimination of Conventional Shoring

- Once aesthetic lodge logs are used to provide shoring for custom engineered Quad-Deck panels, inexpensive and beautiful natural pine or fir decking will be used (in place of more expensive sheetrock) prior to putting Quad-Deck panels in place.
- This innovative technique can largely reduce labor associated with conventional shoring while adding substantial value and warmth to home.

Paneling, Edge V roof Decking, and Flooring

Flooring & Siding Alternatives

- Natural pine and fir products can also provide economic alternatives to conventional hardwood flooring and siding.
- Treated products can be used in similar fashion as conventional siding, providing either a modern look or a rustic pine look.
- Covered areas sheltered from the sun and elements are ideal for exterior applications using softwood siding.

1x6 Douglas Fir
End Matched Flooring

Wavy Edge Bevel Siding

Wavy Edge Bevel Siding

Green Building Approach

- The PHMH will be built almost entirely from beetle kill pine, and its blue tinged wood will line the inner sanctum including log/beam accents, cabinets, ceiling paneling, flooring, and deck.
- The wood for the railings, posts, stairs & cabinets will come from nearby Idaho and PNW forests that have been drastically impacted from by ‘beetle-killed’ pine trees.
- While having drastic ecological impacts, this situation has also created a surplus of timber. All of the lumber used for the PHMH will be milled locally, likely coming from within a 75 mile radius where the house will be built.

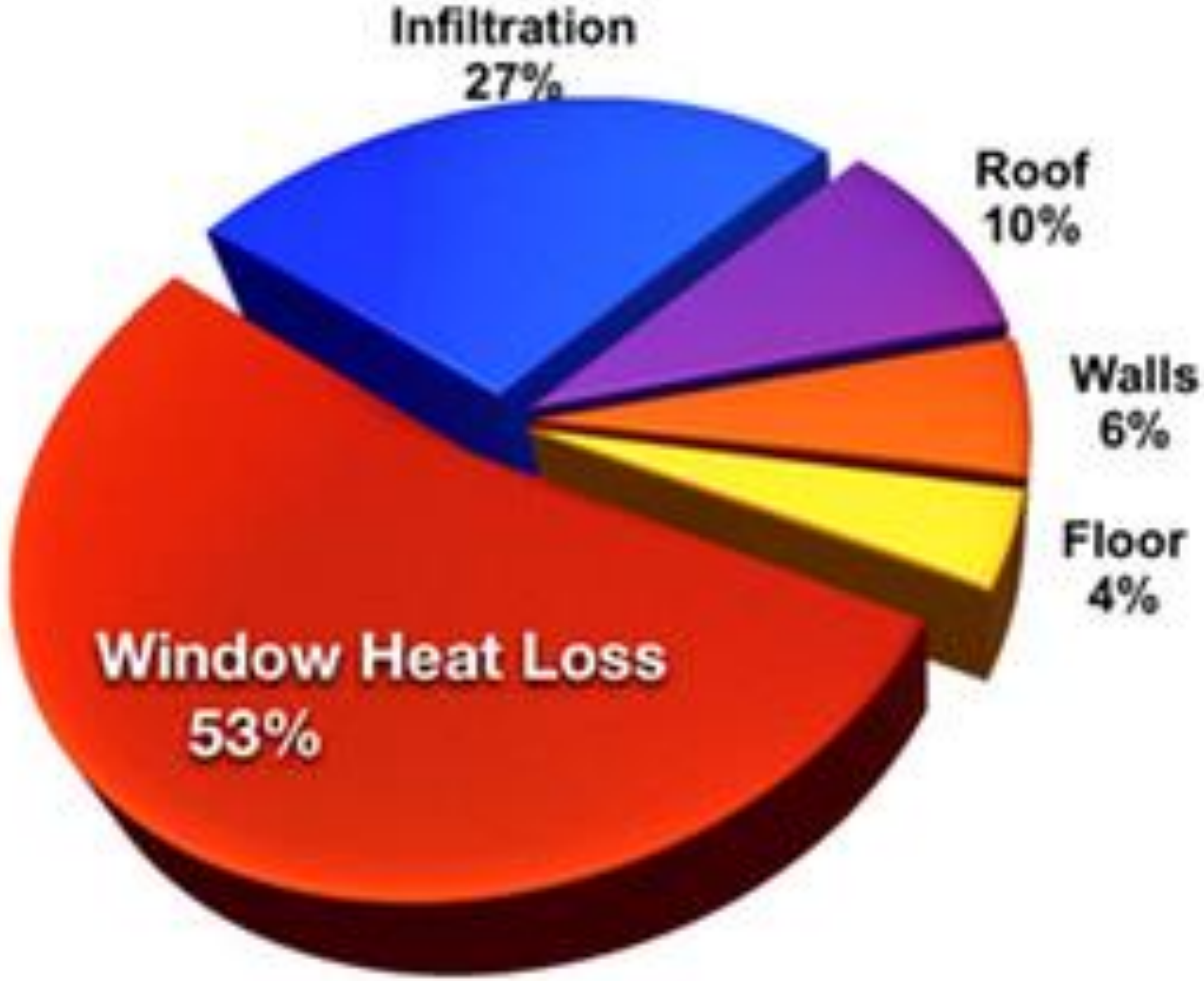
Cabinets & Heavy Items

- Chalk lines will be utilized to mark location of cabinets on ICF walls before decking, paneling and drywall installation.
- ½-3/4” plywood (or other thickness depending on paneling, decking, or drywall thickness) will be fastened to the ICF wall using spray foam and screws via the plastic tie flanges inside the cabinet area.
- Decking or drywall will then be installed by butting up to the cabinet plywood.
- When necessary, concrete anchor bolts can be utilized to secure heavy items.

Reducing Window Heat Loss

- Heat loss from infiltration, walls, floor and ceiling/roof can be reduced by over 95%.
- Hence, for passive house design with tight structures and superinsulation, windows and doors are the single greatest losses of energy.

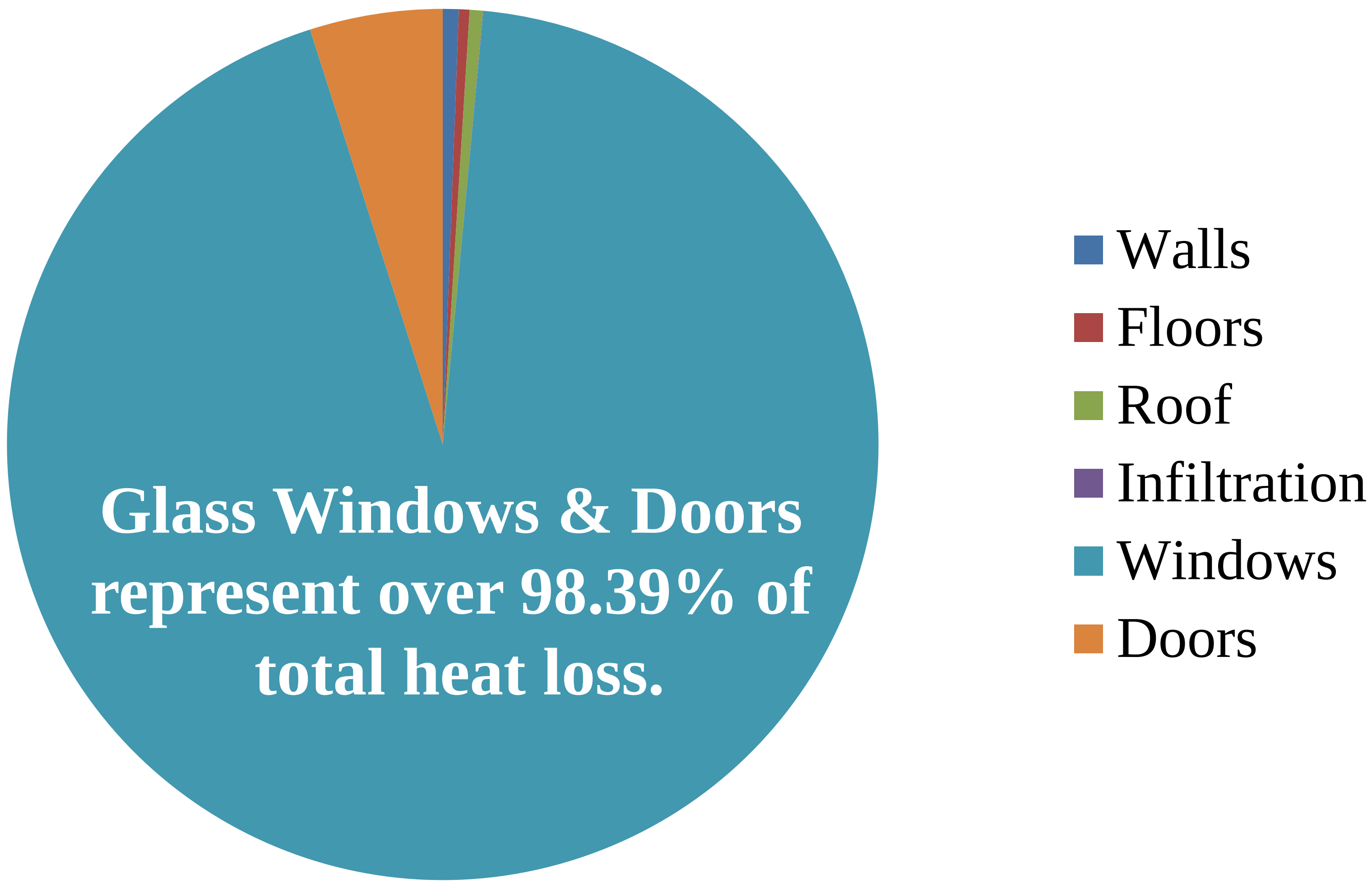
Conventional Window Heat Loss



Radiant Window Technology

- If heat loss for windows can exceed over 50% of energy loss for a conventional structure, for a passive house heat loss from windows could potentially exceed 90%.
- New radiant window technology can not only reduce heat loss, but potentially provide the soul heating source for passive house structures with less than 5 Btu/sf peak heating loads.

Passive House Glass Windows & Doors Heat Loss



Power*e Glass Technology

- Power*e Glass solves the window heat loss problem by using a safe electric current to increase the temperature of the entire inside glass pane of windows and partitions.
- By increasing a window's temperature, Power*e Glass heats and insulates - stopping heat loss at the point where it occurs.

Radiant Glass Windows

- Power*e Glass windows are enhanced industry standard two pane insulated glass units that dynamically create an efficient thermal barrier at the windows.
- Independent tests show that a Power*e Glass heating system:
  - Provides better thermal comfort than other heating systems
  - Uses substantially less power than conventional heating systems.

Advantages of Radiant Windows

- Power*e Glass is a green technology that can save power and money. By eliminating or reducing heat loss, Power*e Glass can:
  - Reduce the need for other heating systems
  - Reduce the energy used for heating
  - Reduce heating costs
  - Enable lower room air temperatures
  - Eliminate condensation and fogging on windows

Proven Window Technology

- The Power*e concept is simple. At its core, Power*e Glass is a proven industry standard double paned window. By touching the glass pane, you can feel the warmth of the thermal barrier created by the Power*e Glass.
- However, the electric current flows safely and invisibly without wires across the metal coating on the other side of the glass pane where it cannot be touched.

Patented Design

- The unique patented continuous glass/metal contact of the Power*e Glass efficiently heats the glass.
- As a result, Power*e Glass uses less power and is more robust than other systems.
- It actually conserves about 85% of the energy, reflecting it back into the structure.
- It operates on DC power, revealing that it can eliminate the 15% loss for DC to AC inverters typically required for solar PV power systems.

Radiant Heat Technology

- Like the light from a lamp, Power*e Glass windows quickly cast a warm heat that is absorbed and re-radiated until all of the occupants and room surfaces become evenly comfortable.
- Power*e Glass windows provide comfort at lower room air temperatures by increasing the radiant heat in the room. You truly can feel the heat from the Power*e Glass. It works by directly warming you and other objects in the room - not by heating the air.
- Additionally, heated Power*e Glass stops all of the heat otherwise lost through the windows from the interior - essentially giving Power*e Glass windows a higher R-value than other windows.

Insulation, Heat & Comfort

- Power*e Glass provides insulation, heat and comfort. Buildings are heated to offset heat loss which occurs primarily through the windows.
- By raising the Power*e Glass temperature above the room air temperature, this heat loss is rendered to almost nothing. Thus heat loss calculations can be simply changed accordingly.
- By further raising the Power*e Glass temperature, Power*e Glass can provide additional heat and comfort to building perimeters and other areas where more heat and comfort are desired.

Simple Construction

- Power*e Glass windows look like ordinary double paned windows and can be washed and treated like ordinary windows.
  - Power*e Glass windows use only two glass panes to provide better heat and insulation.
  - Other "energy-efficient" windows use complex designs combining gases, three or more glass panes and/or plastic films. Inevitably, these gases leak, and the additional glass panes and films increase the likelihood of failure.
  - Temperatures can be controlled by conventional thermostats and other building climate control systems.
  - Power*e Glass windows are sealed against moisture.
  - Power*e Glass windows have no fans, air handling equipment or moving parts to break and no water lines buried in the foundation, walls or ceilings to leak.

Power*e Box

- The Power*e Glass is powered by the Power*e Box AC or by a low-voltage DC power supply.
- Using 120 VAC, each Power*e Box AC can power up to three Power*e Glass windows or units and may be located nearby or remotely from the Power*e Glass.
- Although typically 35 sf or smaller, these Power*e Glass units may be 50 sf or larger depending upon glass sizes, available power supplies, and heating requirements.

Power*e Box cont.

- A Power*e Box AC operates in either Thermostat Mode or in Glass Temperature Mode.
- In Thermostat Mode, a standard thermostat monitors the air temperature of the room and turns the Power*e Box and Glass off and on as needed.
- In Glass Temperature Mode, a Power*e Box AC monitors and keeps each Power*e Glass unit at one of three preset target temperatures (low - medium - high).
- The target temperatures are designated by the customer, and the target temperature for each Power*e Glass unit may be separately changed as required.

Radiant Window Tests

- Independent tests have consistently shown that heated windows do not lose more heat or power to the outside as outside temperatures become colder.
- That is, heated windows do not lose their efficiency as the weather becomes colder due to the insulating effect of the heated glass, the relative heated glass temperature and the lower room air temperature, the low-e glass coatings used, the air gap between the glass panes and other factors.

Radiant Window Tests cont.

- In 2007 and 2008, Kansas State University (KSU) tested the Power*e Glass using their climate chambers and computer simulations and found comparable results.
- This radiant glass methodology has been validated in more than six ASHRAE research projects over the last 15 years, the DOE ENERJOY case study and numerous additional energy management studies reported in ASHRAE symposiums, papers and articles.
- ABOVE is unique as a dynamic program that may be used to accurately model building design, space by space, in addition to standard envelope HVAC sizing.

Radiant Window Tests cont.

- For the purposes of this particular study, the students at KSU modeled a room that was 14 ft. long by 10 ft. wide, with a ceiling height of 9 ft. The room had one window in it, and the window was sized at 5 ft. high by 6 ft. wide.
- The R values that were modeled were R-12 for the walls, no heat loss for the ceiling or the floor (centrally located on the middle floor of a three-floor building) and R-3.85 for the window. The model was exposed to operating temperatures of 10°F and 20°F outside, maintaining 70°F inside.

Radiant Window Tests cont.

- What was found was that with an operating temperature of the glass at 123°F, the mean radiant temperature in the room was an average of 71.6°F compared to 66.6°F for the forced air system.
- This means that the human comfort factor was positively affected by the presence of the warm window surface, and the normal negative effect of a cold window on human comfort was completely avoided.

Radiant Window Tests cont.

- As for thermal operating efficiency, the window was compared in operating wattage to maintaining a good human comfort factor against a forced air heating system.
- Basically stated, the application of the heated window system in the model the students developed resulted in a net reduction of energy Btu/hr. to the tune of 92% of the room's heat loss before the introduction of the radiant window.
- Though results may vary, the potential for reducing energy consumption of a given building by eliminating the basic window conductive losses are typically around 25% to 50% and more depending upon the building's glazing ratio to square footage ratio.

Radiant Window Tests cont.

- The building's conductive losses, infiltration losses and the typical duct losses associated with the operation of a forced air system all are lowered through the use of the heated window, as was proven by the ABOVE study performed by Kansas State University.

2007 Radiant Window Tests

- Among their findings KSU concluded that Power*e Glass windows:
  - Substantially reduce the need for other heating systems.
  - Produce more consistent and comfortable room conditions than natural gas forced air heating.
  - Direct 85% of their power to heat the interior - regardless of outside temperatures.
  - Stop virtually all building heat loss through the heated glass.
  - Create heated zones that complement other heating systems by reducing a building's heat load.

2008 Study

- Using the 2007 information and other data, KSU's 2008 study used an ABOVE computer simulation of a multistory Chicago office building to compare a natural gas heating system and a Power*e Glass system.

Custom Made

- Made to the customer's specifications, Power*e Glass can be combined with clear, tinted, patterned, opaque, laminated or other glass and may be incorporated into industry standard wood, vinyl, fiberglass, metal frames or other custom enclosures.
- Power*e Glass may be used in new construction or as part of building remodeling.

Radiant Glass Applications

- Power*e Glass units can be used as windows, glass walls and panels, and glass divider walls for cubicle conditioning in the core of the building.
- Power*e Glass units can be integrated into windows, walls, interior partitions and other architectural products and can be installed into new construction or retrofitted into existing buildings.

Operating Parameters

- The maximum Power*e Glass temperature is 130ºF.
- A Power*e Box AC operates in either Thermostat Mode or in Fixed Temperature Mode. In Thermostat Mode, a standard thermostat monitors the air temperature of the room and turns the Power*e Box and Glass off and on as needed. In Fixed Temperature Mode, a Power*e Box AC monitors and keeps the Power*e Glass at a preset temperature.
- Power*e Glass DC typically operates between 85ºF and 100ºF.
- The Power*e Glass warm-up time from power off is typically 10 minutes or less.

Power*e Glass Units

- Standard Power*e double paned insulated sealed window manufactured by Radiant Glass Industries LLC incorporating Pilkington TEC-15™ tempered low-e safety glass (inside glass pane) and any tempered clear, tinted, patterned, opaque or other glass (outside glass pane).
- Typical maximum glass size is 35 ft2. Larger sizes are available by special order. Overall unit thickness can be specified from 5/8 inches (15.875 mm) to 11/16 inches (26.9875 mm).
- Power*e Glass units are sealed using a reactive hot melt butyl sealant. All electrical heating components are sealed within the unit except for electric and control wires that extend from one corner of each unit to the Power*e Box AC or DC power supplies.

Power*e Box

- Power*e Glass may be powered by 120 VAC Power*e Boxes or by low-voltage DC power supplies.
- A Power*e Box AC may power up to three Power*e Glass units.
- A DC power supply may power up to several Power*e Glass DC units depending upon their size and power needs.
- In Thermostat Mode, the Power*e Box AC and Glass is controlled by any standard thermostat or building system.
- In Fixed Temprature Mode, a Power*e Box AC monitors and keeps the Power*e Glass at a preset fixed temperature.
- A DC power supply typically monitors and keeps the Power*e Glass DC at a preset temperature.
- Power supplies sized to the Power*e Glass are required.

Safety Features

- Power*e systems incorporate a number of safety features including tempered glass, automatic glass temperature monitoring and automatic power cutoff for excessive operating temperatures or glass breakage.

Heat Pump Technology

- For climates with moderate heating and cooling needs, heat pumps offer an energy-efficient alternative to furnaces and air conditioners.
- Like refrigerators, heat pumps use electricity to move heat from a cool space to a warm space, making the cool space cooler and the warm space warmer.
- During the heating season, heat pumps move heat from the cool outdoors into your warm house and during the cooling season, heat pumps move heat from your cool house into the warm outdoors.
- Because they move heat rather than generate heat, heat pumps can provide up to 4 times the amount of energy they consume.

Heat Pump Efficiency

- The most common type of heat pump is the air-source heat pump, which transfers heat between the structure and the outside air.
- In contrast to heating with electricity, a heat pump can trim the amount of electricity you use for heating by as much as 30% to 40%.
- High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort in summer months.
- However, the efficiency of most air-source heat pumps as a heat source drops dramatically at low temperatures, generally making them unsuitable for cold climates, although there are systems that can overcome the problem.

Geothermal Heat Pumps

- Geothermal (ground-source or water-source) heat pumps achieve higher efficiencies by transferring heat between a structure and the ground or a nearby water source.
- Although they cost more to install, geothermal heat pumps have low operating costs because they take advantage of relatively constant ground or water temperatures.
- Whether a geothermal heat pump is appropriate for you will depend on the size of your lot, the subsoil, and the landscape.
- Ground-source or water-source heat pumps can be used in more extreme climates than air-source heat pumps, and customer satisfaction with the systems is very high.

Geothermal Heat Pump Economics for New Construction

- Even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the industry ROI is currently less than 5 years.
- For new construction of passive house technology in which energy loads are reduced by 90%, HVAC tonnage can be reduced proportionately and field loops buried in the structure’s footings.
- This results in substantially reducing initial costs for installation of geothermal and radiant systems, allowing for an immediate net increase in cash flow for new mortgages, allowing for installation of solar PV power systems to achieve net-zero homes.

Geothermal Heat Pump System Life Cycle

- System life is estimated at 25 years for the inside components and 50+ years for the ground loop.
- There are approximately 50,000 geothermal heat pumps installed in the United States each year.

Advanced Heat Pump Features

- Variable speed compressors, blowers and water pumps
- Desuperheaters
- Scroll compressors (often used in air source mini-splitter technologies which are designed for use in isolated locations without requiring ducts, such as retrofitting existing HVAC systems during remodeling)
- Automated Controls

Variable Speed Capacity

- Some models of heat pumps are equipped with *variable-speed* fans (blowers), compressors and water pumps.
- The variable-speed controls for these heat pump components attempt to keep the air moving at a comfortable velocity, minimizing cool drafts and maximizing electrical savings.
- It also minimizes the noise from the blower running at full speed.

Desuperheater

- Many high-efficiency heat pumps are equipped with a *desuperheater*, which recovers waste heat from the heat pump's cooling mode and uses it to heat water.
- A desuperheater-equipped heat pump can heat water 2 to 3 times more efficiently than an ordinary electric water heater.

Scroll Compressors

- Consists of two spiral-shaped scrolls. One remains stationary, while the other orbits around it, compressing the refrigerant by forcing it into increasingly smaller areas.
- Compared to the typical piston compressors, scroll compressors have a longer operating life and are quieter.
- According to some reports, heat pumps with scroll compressors provide 10° to 15°F (5.6° to 8.3°C) warmer air when in the heating mode, compared to existing heat pumps with piston compressors.

Air Source Heat Pumps

- Air source heat pumps have limitations in cold environments (they cannot deliver warm air after the outside temperature drops below freezing).
- When outdoor temperatures fall below 40°F, a less-efficient panel of electric resistance coils, similar to those in your toaster, kicks in to provide indoor heating.
- This is why air-source heat pumps aren't always very efficient for heating in areas with cold winters.
- Some units now have gas-fired backup furnaces instead of electric resistance coils, allowing them to operate more efficiently.

Dual-Source Heat Pumps

- A dual-source heat pump combines an air-source heat pump with a geothermal heat pump.
- These appliances combine the best of both systems.
- Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units.
- The main advantage of dual-source systems is that they cost much less to install than a single geothermal unit, and work almost as well.

Ground/Water Source Heat Pumps

- Geothermal heat pumps (GHPs), sometimes referred to as geoexchange, earth-coupled, ground-source, or water-source heat pumps, have been in use since the late 1940s.
- They use the constant temperature of the earth as the exchange medium instead of the outside air temperature.
- This allows the system to reach fairly high efficiencies (300% to 600%) on the coldest winter nights, compared to 175% to 250% for air-source heat pumps on cool days.

Ground/Water Source Heat Pumps cont.

- Although many parts of the country experience seasonal temperature extremes -- from scorching heat in the summer to sub-zero cold in the winter—a few feet below the earth's surface the ground remains at a relatively constant temperature.
- Depending on latitude, ground temperatures range from 45°F (7°C) to 75°F (21°C). Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger.

Heating, Cooling & Hot Water

- As with any heat pump, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water.
- Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

Closed Loop Geothermal Heat Pump

- For the PHMH, ground coils for the geothermal heat pump will be shared with the ERVs.
- Coils will be placed around the footings of the PHMH.
- Since the energy load of the super-insulated PHMH will be reduced by 90%, the heating and cooling requirements will be reduced proportionately as will the field loop requirements.
- This will substantially reduce costs for installing efficient variable capacity ground-source heat pumps.

Earth-Coupled Heat Pumps

- Heating, cooling and hot water can account for as much as 75% of the total energy cost in a typical home or commercial building.
- Capacity-on-demand heat pumps are the most cost effective solution to all three energy sources.

Variable Speed System Control

- The variable capacity system control consists of developing an automated operating system (software) integrated with a control board (hardware) that replaces the current three phase operating systems.
- This automated system will provide seamless variable speed control for secondary circuits including the compressor, fan/blower, and possibly the water pump.

Revolutionary Heat Pump Efficiency

- Variable capacity heat pumps automatically match the energy draw with energy demand in real time, optimizing energy efficiency unlike any other HVAC system available today.
- With ECM motors and options for multiple compressors or a 100% variable speed compressor, they consume energy at a level comparable to the production of your system… every minute of every day.
- In a compelling side-by-side comparative analysis at Langley Air Force Base, the capacity-on-demand system used significantly less power (an average of 51% less power) than a leading national brand to condition the same space. The test was conducted during July 2011 at Langley Air Force Base, Hampton, Virginia.

Geothermal Heat Pump Energy Tax Credit through 2016

- Taxpayers installing systems for their residence are eligible for the Residential Renewable Energy Tax Credit, a tax credit equal to 30% of the geothermal system including installation costs.
- Taxpayers installing systems on commercial property are eligible for the Business Energy Investment Tax Credit (ITC), and tax credit equal to 10% of the geothermal system including installation costs.
- There is no cap on either of the federal tax credits and the 2016 time frame may be extended.

WaterFurnace Synergy3D Geothermal Heat Pump Series

Multi-stage heating and cooling

- 23.7 EER / 4.5 COP (ARI 13256-1 GLHP)
- 3-6 ton
- Hot water generation
- Integrated Radiant Heat

WaterFurnace Synergy3D Performance

- The WaterFurnace Synergy3D series provides forced air heating, cooling and hydronic heat (but no hydronic cooling) for radiant floors in one convenient package.
- It was engineered with leading edge components including Copeland scroll compressors, and takes efficiency to new levels.
- Compared to ordinary furnaces and air conditioners, Synergy3D can provide savings up to 60%.
- When coupled with today's best thermostats and an integrated monitoring system, the Synergy3D will provide comfort and reliability.

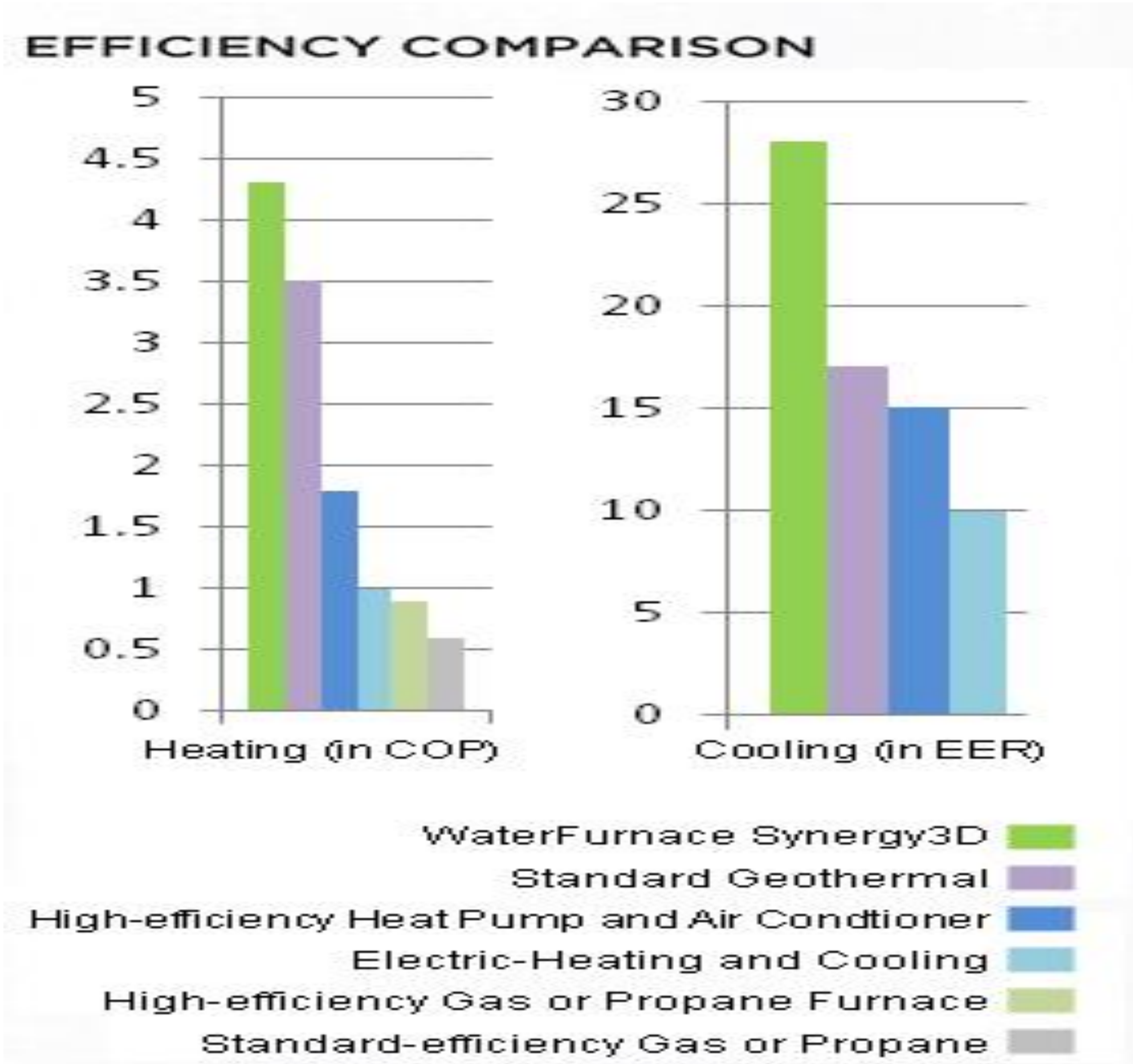
WaterFurnace Synergy3D Features

- Variable speed ECM blower motors are used for quiet operation.
- A sophisticated microprocessor control sequences all components during operation for optimum performance, and provides easy-to-use troubleshooting features with fault lights and on-board diagnostics.
- To help achieve ultimate comfort, heating priority may be given to forced air zones or radiant floor heat.
- The Synergy3D system is ideal for seasonal hydronic heating and forced air cooling

State-of-the-Art Efficiency

- The WaterFurnace Synergy3D series can dramatically reduce annual costs for heating, cooling and hot water often as much as 70%!
- No other gas furnace, air conditioner or heat pump comes close to Synergy3D's efficiency.
- WaterFurnace dealers utilize GeoLink Design Studios, a sophisticated software package designed to ensure proper design and sizing of WaterFurnace geothermal systems.
- WaterFurnace dealers have access to exclusive audit software designed to estimate heating and cooling costs based on square footage, construction style and climate.

Synergy 3D Efficiency Comparison



Synergy3D Series Technology

- Radiant heat (hydronic) is widely regarded as the most comfortable way of heating the home, while forced air is typically the most cost effective.
- The Synergy3D series combines the best of both worlds, providing the luxurious comfort of radiant heat for basement and bathroom floors while providing traditional forced air heating and cooling for the rest of the home.
- This approach eliminates the need to purchase a dedicated hot-water unit for radiant heat, a furnace for the rest of the house, and an air conditioner to cool in the summer.
- The Synergy3D does it all in one convenient package, using environmentally-friendly R410A refrigerant, dual capacity scroll compressors, and the unmatched energy efficiency of geothermal technology.

Synergy3D Design

- The Synergy3D unit will provide forced air heating and cooling to ducted zones, while also providing hot water to radiant floor zones.
- WaterFurnace systems are the result of state-of-the-art research and development.
- Dozens of quality checks are performed throughout the assembly process.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Synergy3D Design cont.

1. Blower Motor: A variable speed ECM blower motor with up to 12 airflow selections allows the unit to provide enhanced comfort, quiet operation and energy savings.

2. Cabinet: The cabinet is finished with a durable silver metallic finish for long lasting beauty and protection. Fully insulated for quiet operation with cleanable, foil backed insulation. New exterior design elements put the unit in the same class as today's stylish high-end appliances.

3. Coated Air Coil: Our exclusive FormiShield coating on the air coil resists corrosion and increases equipment life. Its large size improves efficiency and dehumidfication during cooling.

Synergy3D Design cont.

4. Drain Pan: Electronic overflow protection is included to eliminate the possibility of condensate flooding. Constructed of plastic the drain pan is also corrosion proof and resists bacterial growth.

5. Hot Water Assist: The Synergy3D preheats the water and delivers it to the water heater. The longer the unit operates, the greater the amount of hot water generated. In the heating mode, the hot water is generated at the efficiency of the unit. In cooling, waste heat is recovered and hot water is free!


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Synergy3D Design cont.

6. Compressor: Copeland Scroll compressors are featured in all Synergy 3D products. Superb efficiency and reliability. Dual capacity units include Scroll UltraTech compressors. Mounted on double-isolation plates for extra-quiet operation.

7. Controls: Sophisticated microprocessor control sequences components to provide ultimate performance. Onboard diagnostics allow for easy service. Controls communicate with thermostat to display service messages. ComfortAlert module monitors compressor operation for added reliability and easy troubleshooting.

Synergy3D Design cont.

8. LED Status Lights: Externally-mounted status lights indicate normal operation or display faults and assist the technician in troubleshooting.

9. Hydronic/ Radiant Heat: Hot water for in-floor radiant heat is generated at a fraction of the cost of ordinary boilers. Typically, the WaterFurnace GeoTank is connected to the Synergy3D to store and distribute the heated water. Floors covered in tile, wood, vinyl or stone are kept toasty warm, even on the coldest days. Heating is also accomplished using forced air through the duct system.)

Synergy3D Performance

- During the cooling season, the system will automatically reverse to provide cool, dehumidified air for air conditioning through the duct system.
- Quietly and efficiently --with no noisy, outdoor unit to detract from the peacefulness of your backyard. Synergy3D allows you to enjoy your environment, inside and out.
- And because this system uses geothermal technology, you can be assured of low operating costs, minimal maintenance, long equipment life and quiet operation.

WaterFurnace Series 7 & NDW

- A more versatile and efficient alternative to the Synergy3D Series is the Series 7 water to forced air with an NSW or NDW Hydronic unit dedicated to producing hot and cold water for the structure including radiant heating and cooling.
- In contrast to the Synergy3D system, the ultra-high efficient Series 7 geothermal heap pump and NSW radiant systems operate independently.
- The Series 7 uses an advanced proprietary 100% variable capacity heat pump, blower and water pump system which is more efficient than the two stage scroll compressors used in the Synergy3D (EER 41/5.3 COP compared to 23.7 EER/4.5 COP for Synergy3D, and 24 EER for the NDW).

WaterFurnace 7 Series™

- *41.0 EER / 5.3 COP (ARI 13256-1 GLHP)*
- *3 - 5 Ton – R-410A Refrigerant*

WaterFurnace 7 Series™ cont.

- The WaterFurnace 7 Series™ provides homeowners the ultimate in comfort and performance and represents our finest products.
- The 700A11 signifies groundbreaking innovations on multiple fronts – most notably as the geothermal industry's first fully launched variable capacity residential unit and the only unit to surpass both the 41.0 EER and 5.3 COP efficiency barriers.
- These ratings are vastly greater than ordinary conditioning systems and 30% higher than current two-stage geothermal heat pumps.

WaterFurnace 7 Series™ cont.

- Their Aurora communicating controls work in unison with variable capacity technology.
- A variable capacity compressor, variable speed loop pump, and variable speed blower motor combine to offer an unprecedented level of comfort.
- While other conditioning systems run at one or possibly two capacities (high and low), the 700A11 scales compressor output and airflow to exactly the level needed for any heating or cooling situation.

WaterFurnace 7 Series™ cont.

- The 7 Series can ramp down to 20% of normal operation for the ultimate efficiency and comfort or scale up to 130% output using SuperBoost™ cooling.
- Their exclusive SuperBoost mode is for brief periods when extra conditioning is needed and ensures guests stay cool and comfortable during summer get-togethers.
- Because the 700A11 operates over the industry's largest range of capacities (from 20-130%), it provides unmatched humidity control and can entirely eliminate the need for auxiliary heat in cold-weather climates.

WaterFurnace 7 Series Design Components

1. Unit Cabinet:

The cabinet comes with a professional grade finish for long-lasting beauty and protection.

The system is fully insulated for quiet operation with cleanable foil-backed insulation.

WaterFurnace 7 Series™ Design Components cont.

2*. **Advanced Hot Water Generation:***

With an optional hot water assist, the 7 Series preheats your water and delivers it to your water heater.

A sophisticated microprocessor controls and monitors heat pump conditions and determines when there is excess heat available to route to the hot water heater.

This allows you to utilize heat in the most efficient way possible.

WaterFurnace 7 Series™ Design Components cont.

3. Coated Air Coil:

Their exclusive FormiShield™ Plus coating resists corrosion and increases lifespan.

Its patented “11 element” fin technology and large size improves efficiency and dehumidification during cooling.

WaterFurnace 7 Series™ Design Components cont.

4. Aurora Interface Diagnostic Port:

WaterFurnace is the first to offer an external communication port, which allows service and diagnosis of their units without ever having to open them.

5. ThermaShield™:

Their exclusive coaxial heat exchanger coating protects against condensation for temperatures below 50°F, extending its life.

WaterFurnace 7 Series™ Design Components cont.

6. Variable Capacity Compressor:

WaterFurnace was the first geothermal brand to offer two-stage units.

They were the first to launch residential variable capacity units.

Variable capacity compressors offer soft start capabilities and gently ramp up to speed for quiet operation while also eliminating light flicker.

WaterFurnace 7 Series™ Design Components cont.

7. Aurora Controls:

Aurora Controls offer full two way communication between components, advanced operating logic and robust troubleshooting capabilities.

It carries support for true energy monitoring, extended hot water generation control and integration with their IntelliZone2 zoning system.

Incorporating the upcoming Aurora Web Link (AWL) module also extends communication protocols to include the internet, smart grids, home automation networks and more.

WaterFurnace 7 Series™ Design Components cont.

8. Blower Motor:

WaterFurnace was the first to offer variable speed blowers for geothermal equipment, and now they are improving upon that by adding two way communication capabilities.

A variable speed ECM motor runs at only the speed needed for maximum efficiency and savings.

When Active Dehumidification is enabled, their Aurora Controls optimize the blower to maximize moisture removal.

WaterFurnace 7 Series™ Design Components cont.

9. Filter and Filter Rack:

Pleated MERV 11 filter is standard while an optional pleated MERV 13 is available for improved air quality.

The filter rack holds 1” or 2” filters and is field convertible.

Envision Series NSW

- *17.5 EER / 3.1 COP (ARI 13256-2 GLHP)*
- *1.5 – 6.0 ton hydronic heat pump*
- *High volume hot water or chilled water*

NSW Hydronic Heat Pump

- The wide range of operating temperatures, compact size, reversible control box and piping enable the NSW hydronic heat pump to be used in a variety of applications for both radiant and forced air heating and cooling.
- These include pool/spa heating, radiant floor, snow melt, aquaculture, and process water installations.
- NSW units can be used for heating only, cooling only (field converted for chilled water applications), or heating/cooling.

NSW Hydronic Heat Pump cont.

- A sophisticated microprocessor controls the pumps and compressor by sampling the entering water temperature.
- The controller enables the user to view all modes of operation and easily adjust temperatures.
- All fault conditions are monitored by the controller to ensure safe, reliable operation.
- The NSW cabinet is fabricated from heavy-gauge steel and finished with a corrosion-resistant polyester coating to provide years of durability and beauty.
- Scroll compressors, R-410A refrigerant, and oversized heat exchangers combine to provide the user with exceptional energy savings.

Envision Series NDW Hydronic Unit

- *15.8 - 22.5 EER / 2.7 - 3.5 COP for closed loop systems (ARI 13256-2 GLHP)*
- *8-15 ton hydronic heat pump*
- *High volume hot water or chilled water*

Envision Series NDW Hydronic Unit

- The Envision Series NDW is designed to meet the high-volume water demands of today's larger luxury homes.
- NDW units provide high capacity heating and cooling performance, but still deliver the features homeowners have come to expect from their Envision line.
- They can deliver almost four dollars of heat for every dollar of electrical energy used.
- That translates into an efficiency rating of 400% compared to the best ordinary furnace that delivers less than $0.97 of energy for every dollar spent on expensive fossil fuels.

Radiant Floor Heating

- Experience luxurious comfort throughout the room from head to toe.
- Floors are kept toasty warm, even on the coldest days.

Domestic Hot Water

- Homes with large demands for domestic or potable water heating will benefit from the exceptional efficiency of NDW units.
- When used in conjunction with another WaterFurnace geothermal unit to condition the air inside the home, the complete system provides the ultimate in savings, comfort, and safe, reliable, quiet performance.

Pool Heating & Snow/Ice Melt

Pool Heating

NDW units can also be utilized to heat water for pools and spas for much less than an ordinary pool heater.

Snow/Ice Melt

Keep your sidewalks or driveway free of ice and snow during the cold winter months. Eliminate the hazards of walking on ice-covered sidewalks, and reduce the need to shovel snow.

Envision Series NDW
Hydronic Unit Design Features cont.

CABINET:

The NDW unit cabinet is fabricated from heavy gauge steel and a durable metallic finish for long lasting beauty and protection.

Large lift out panels provide access from all four sides and controls that can be placed on either end (allowing piping to be located on the front or at the back) improves serviceability.

Envision Series NDW Hydronic Unit Design Features cont.

CONTROLS:

A microprocessor controls the load pump, source pump and compressor by sampling tank temperatures within the GeoTank (see back page).

A robust controller enables the user to view all modes of operation and easily adjust temperatures.

All fault conditions are monitored by the controller to ensure safe, reliable operation.

Although sophisticated in its operation of the unit, the control is easy to adjust using a single mode button, up/down arrows for temperature setting, and an LCD screen which displays current temperature and settings.

Envision Series NDW
Hydronic Unit Design Features cont.

COMPRESSOR:

Two high efficiency scroll compressors keep operating costs low and will provide years of reliable operation.

Sound attenuating compressor blankets and double isolation mounting plates are used in every unit for “whisper-quiet” operation.

Envision Series NDW
Hydronic Unit Design Features cont.

Soft Start:

IntelliStart™ reduces the amount of current needed to activate the unit by 70%.

This helps alleviate light flicker, reduces start-up noise and increases compressor life.

For those with self-sufficient homes, IntelliStart allows WaterFurnace units to run off-the-grid.

Envision Series NDW
Hydronic Unit Design Features cont.

Brazed plate heat exchangers:

Provide increased efficiency, performance, and reliability.

Because they're much smaller than traditional coaxial exchangers, they allow NDW Series units to provide high capacity performance in a compact unit.

Water to Water vs. Water to Air

- Typically, ground or water source heat pumps are most efficient when used in water to water applications such as radiant heating and cooling.
- However, radiant systems, particularly cooling, are not efficient when utilized with wood flooring or carpeting.
- Radiant systems also have issues with condensation, though modern control systems such as techmar have developed solutions that monitor and control the dew point.

Temperature Overshoot

- In a home with a tight envelope and a very small heating load, even a small amount of heat can cause overheating, and the thermal mass in a radiant floor system (especially with concrete-slab systems) increases the risk of overheating.
- This is particularly true in buildings with some level of passive solar gain—the radiant floor may still be delivering heat even after solar gain raises the air temperature.
- Geothermal radiant systems are best suited to combat this since the systems are more efficient at generating heat at lower water temps.
- Outdoor Reset can be used so the tank temperature will be based on the outdoor temperature to avoid overheating.

Maintaining Slab Temperature

- When the heating load is very small, the radiant slab has to be maintained at no more than a few degrees above room temperature to prevent overheating, and this means that the slab isn’t likely to be warm to the touch.
- A slab maintained at 74°F (23°C) will be cooler than an occupant’s skin, so bare feet will conduct heat into the slab.

Radiant Floor
Warm Weather Shut Down

- To keep the level of heat input proportional to the actual needs of the space (keeping in mind solar gains), there are programming options available, including scheduling floor minimum temperatures, using setback, and a tekMar feature called Radiant Floor Warm Weather Shut Down.
- The latter will hold off the radiant installation until the outdoor temperature is sufficiently low, to avoid overheating in the afternoons during the shoulder seasons.
- In buildings that experience solar gain, radiant floor cooling is the most efficient option, as it will remove the heat from the floors before it has a chance to heat the air.

Indoor Temperature Feedback

- Another benefit to modern controls is Indoor Temperature Feedback, whereby thermostats communicate with the master control to provide ACTUAL heating or cooling needs.
- This prevents needless overheating or cooling, and allows the control to respond to unexpected environmental gains or losses.

Temperature of Radiant Floors

- Radiant floors are not usually warm to the touch, they typically feel neutral (with the exception of slab warming in bathrooms).
- A neutral colored floor can add a lot of heat to the room through radiation, as it is still warmer than the ambient air.
- Floors that are warm to the touch, bathrooms aside, are typically seen on cold days in buildings where the heat loss is appreciable

Expense of Radiant Systems

- Expense can be an issue with radiant installations, but there are design options that can reduce these costs (for example, a heat exchanger off a highly efficient water heater).
- As for energy savings, it is undeniable that water transfers much more energy than air.
- Thus, the energy required to operate a blower fan vs. a hydronic pump is much higher.

Ground-Source
Forced Air Heat Pump

- For homes that use wood floors, carpet, and solar passive design, integration of forced air delivery to ground-source heat pumps provide the best heating and cooling options.
- Though some energy efficiency may be lost due to water to air conversion, the installation of ducts is less expensive than installing radiant floor systems.

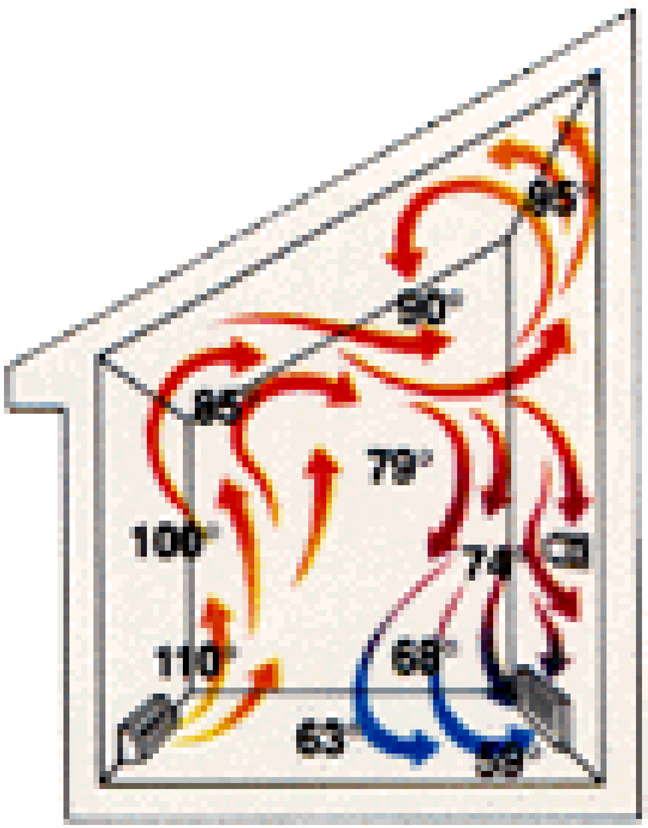
Radiant Heating & Cooling Technologies

- Provides state-of-the-art energy efficiency and comfort for heating and cooling.
- Water and concrete are substantially more efficient at moving and distributing thermal energy than forced air.
- Warm and cool water circulates through tubing that is encased in concrete floors. This keeps heat where it is needed most.
- Radiant cooling is supplemented with a water to air technology, AirCell, which provides aspiration to enhance radiant cooling.

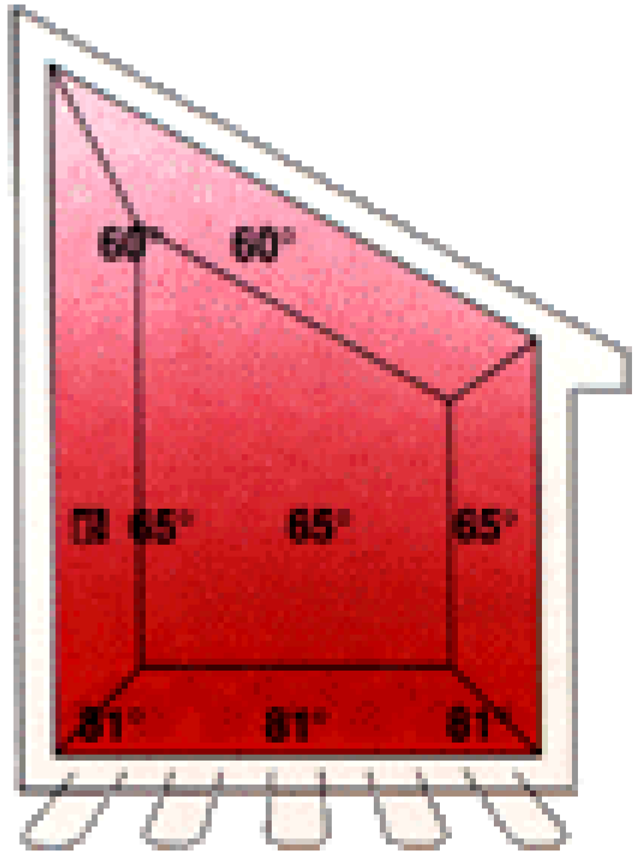
Enhancing Energy Efficiency by over 40%

- Radiant heating allows building occupants to be comfortable at lower thermostat settings.
- This allows for a 40% reduction in fuel costs in comparison with forced air heating.
- Low pressure pumping of water is also significantly less energy intensive than powering blower fans for forced air systems.
- Thus, water to water delivery of heating and cooling, particularly heating, is considerably more energy efficient.

Radiant vs. Forced Air



Forced Air



Radiant Floor

Radiant Heat Saves Energy

- Reducing Parasitic Losses
- Lower Ceiling Temperatures
- Zoning Reduces Energy Usage
- Lower Air Temperatures for The Same Comfort
- Blowing Hot Air Can Cause Cooling

Reducing Parasitic Losses

- Parasitic loss refers to energy lost due to inherent inefficiencies of a system. Duct work in a forced air heating system, for example, can be difficult to permanently seal/insulate and is often located in unheated crawl spaces or basements. As hot air is blown through these large ducts, heat is lost through the tiny flaws in the system and escapes into unknown areas.
- Additionally, when hot air is blown into a room with a door closed, it can cause an increase in air pressure. This pressure pushes the heat through weather stripping on windows. Blowers used in forced air systems on average require 9x the amount of electricity as the pumps in radiant systems. All of these parasitic losses add up in forced air systems add up to a 30-40% less efficient system.

Lower Ceiling Temperatures

- Forced air systems emit hot air at a temperature of approximately 120–140 °F.
- This hot air rapidly rises, creating a temperature zone that can often be over 10 degrees warmer than the air below.
- This stratification effect becomes greater as the ceiling height increases. When ceilings are hot and just below a cold roof, heat loss is quite high.
- It is precisely because of this effect that we insulate ceilings and attics so much.

Zoning Reduces Energy Usage

- Most forced air homes have a single thermostat. In other words, they are single zone systems.
- This is because forced air systems are inherently difficult and therefore, expensive to zone.
- The result is a top story that's too hot, while downstairs remains cool.
- Or rooms facing direct sunlight become overheated while other rooms are inadequately controlled.

Lower Air Temperatures for The Same Comfort

- When we are outside on a warm, sunny day, we may be comfortable in a tee shirt even if the air is only 60 degrees.
- This is because the radiant warmth from the sun allows us to be comfortable at a lower air temperature. The same is true in a home.
- With the warmth emanating from a radiant floor, we can the same level of comfort with the thermostat is set a few degrees lower than needed in forced air home.

Blowing Hot Air Can Cause Cooling

- We can be quite comfortable outside until the wind picks up.
- Even though the temperature has not changed, the movement of air across our skins causes evaporative cooling.
- Paradoxically, hot air blowing from a duct may require you to set the thermostat slightly higher to maintain the same comfort.

Radiant Floor Systems

- When wood floors and padded carpet are not utilized, and passive solar radiation is used to take advantage of temperature swings in desert climates, using modern teckMar controls radiant floor systems can be efficient and cost effective over time.
- Radiant floor systems can also be installed in specific areas that are not normally covered with carpeting or wood floors, such as workshops, garages, mud rooms connected to the garage, bathrooms and laundry rooms where warm floors are desirable, and possibly kitchen and food storage areas.

Radiant Systems are Healthy

- Forced air systems not only blow hot air, they also push allergens, dust and other airborne particles to every room in your home.
- Improved indoor air quality can reduce allergies, medical bills, incidences of asthma and more. European studies indicate that dust mite populations are reduced as much as 90% in radiant heated homes.
- And a quiet, peaceful environment, devoid of noisy fans and blowers), is a healthier and more relaxing environment too.

Viega Climate Mat & Climate Control Technology

- State-of-the-art radiant heating and cooling solutions.
- AutoCad designed by manufacturer for each installation for commercial and large residential applications.
- Reduces labor time for installation by 80%.
- Works well with virtually any floor covering including wood floors and carpet for heating.
- However, wood floors and carpet are no recommended for radiant cooling.
- Manufacturer provides on-site training for contractors.
- Will be used with Waterfurnace's NSW hydronic heat pumps for radiant floor installations.

Viega Pre-assembled Climate Mat

Viega Hydronic Mixing Block

- Simplifies wiring, piping and programming for installation of radiant heating systems.
- The highly engineered hydronic mixing block is a user-friendly and economical solution for controlling radiant heating systems.
- It combines mixing, control, air elimination and a circulator in a single, simple unit that makes wiring, piping and programming easy.

Viega Hydronic Mixing Block cont.

- The hydronic mixing block features only three connections for simple installations, with clearly labeled fittings and ports.
- Piping and controls are often the largest obstacles for installing radiant systems. The hydronic mixing block removes the obstacles with increased functionality, minimized settings and easy connections for piping and wiring.

Viega Hydronic Mixing Block

Small Duct High Velocity Air Delivery System

- Second only to radiant floor technology, small duct high velocity (SDHV) can use hydronic sources of hot can cold water to supplement radiant systems with similar comfort and unprecedented energy efficiency.
- This is accomplished through minimizing the movement of energy through air using the same geothermal heat pump/hydronic system used for radiant heating and cooling.

SDHV Systems Provide Greater Comfort

- SDHV Systems have been independently tested and the results are publicly available.
- A "comfort quotient" was developed specifically to measure "relative comfort".
- SDHV Systems provides twice the relative comfort of conventionally ducted systems.

Advantages of SDHV Systems

- SDHV Systems provide:
  - Most Even Distribution of Temperatures
  - Draft Free operation
  - No "Stratification"
  - Most Comfortable Heating Humidity
  - Most Comfortable Cooling Humidity
  - Fast Temperature Response

Aspiration

- SDHV Systems are designed to "aspirate" or "mix" air at the supply outlets.
- They use smaller (and less noticeable) supply outlets in more locations which results in the most even temperatures possible throughout the conditioned space.

Superior Efficiency & Performance

- SDHV Systems move approximately one quarter of the air, four times as fast as conventionally ducted systems. This makes them very responsive to thermostat temperature settings.
- Based upon the quality of comfort, SDHV Systems are widely acknowledged as providing the best quality air conditioning comfort available, and the second highest quality heating comfort available behind radiant floor heating systems.

SDHV & ERV Ducts

- All mini ducts and vents will be designed into the house plans and blocked out before the ICF is poured.
- The heat and cooling source will be provided by a state-of-the-art 100% variable (20%-130% operation range) capacity system including the compressor, blower and water pump.

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SpacePak Air Cell™ Technology

- 30-50% Less Energy via EC fan motors and Cascading Design
- Heating, Cooling & Ventilation All In One
- Maximize Heat Pump Efficiency
- Simple, Cost Effective, and Virtually Invisible Installation
- Intelligent Integrated Control
- Quiet, Built-in Zones & Uniform Temperatures
- Ideal for use with Hydronic Heat Pumps and integration with Radiant Heating, Hot water & cooling via techMar controls.

SpacePak Air Cell™ Module

30-50% Less Energy

- EC variable speed fan technologies use over **30% less energy** when compared to traditional on/off configurations.
- Over **50% less energy** when used in a cascade fashion with multiple AirCell modules linked through AirCell's integrated control board.
- Provides a 7-15 year ROI for retrofits and can be included with geothermal heat pump systems enabling a 30% tax credit for either remodeling or new construction.
- When ammortized via 30 year loans with new construction the energy savings can be immediate and the mortgage interest deducted.

Heating, Cooling & Ventilation All In One

- AirCell works in conjunction with any water to air hydronic supply system, including:
  - Boilers
  - reverse cycle chillers
  - heat pumps and geothermal

Maximize Heat Pump Efficiency

- When connected to today's high-efficiency geothermal heat pumps, AirCell guarantees ultra-efficiency by utilizing lower supply water temperatures thereby maximizing the performance of the GSHP investment.

Simple, Cost Effective, and Virtually Invisible Installation

- No visual obstacles as seen with other air distribution equipment, keeping your décor as you planned: visually beautiful and ultimately comfortable.
- Installer friendly, ultra-lightweight design is easily installed by a single technician. No thermostat wiring and no bulky main supply plenums to run. Just simple hot and cold water quick-connections and SpacePak's patented 2" flexible distribution with Kwik-Connect System tubing, and you have an instant total comfort solution.

Intelligent Integrated Control

- AirCell's integrated control platform continuously monitors the zone return and water coil sensors while controlling the fan speed and zone dampers in response to the programmed set-points (including on/off times, fresh air percentage, temperature and numerous other custom variables).
- Communication and programming is performed through either traditional, wall-mounted thermostat controls or using a WiFi 802.11 enabled device, including smart phones and computers.

Quiet, Built-in Zones & Uniform Temperatures

- **Whisper Quiet**
  - AirCell operates at 22 dBA @ 3'
- **Built-In Zones**
  - Comes standard with 2 motorized zones complete with individual temperature controls and 4 outlets each.
- **Uniform Temperatures**
  - Like all other SpacePak air distribution systems, AirCell operates using the "Aspiration" principle, which thoroughly blends room air and eliminates temperature stratification while using a much lower volume of input air when compared to traditional systems.

Small Duct High Velocity (SDHV) System

- SDHV systems can provide heating, central air conditioning, air filtration, humidification and outside air to the conditioned space.
- Up to 1100 CFM at outlet compared with 300-500 CFM for conventional HVAC systems
- Removes 30% more moisture than conventional HVAC systems
- Small 2" flexible insulated tubing eliminates large, bulky ductwork
- Quick and easy installation

SpacePak WCSP-G Series

- One-piece central units with coils for use with chilled and/or hot water.
- Units are available with cooling capacities of 1½ (18,000 BTUH) to 5 Ton (60,000 BTUH).
- Horizontal central blower unit with coils for use with water.
- Can be used with ground source geothermal heat pump units.
- Can discharge horizontally through the end or vertically through the top.

WCSP-G Series

Viega Hybrid Copper & PEX

- Time saving PEX tubing and fittings can be used for entire residential applications with the exception of the water meter.
- Both labor and material costs are reduced.

Viega ProPress System

- The ProPress System is the fastest, most reliable, flameless way to press copper tubing.
  - Much faster than soldering (reduce labor by 75%).
  - Safer–no flame.
  - Cleaner–no solder, flux.
  - Convenient–one tool, one source of fittings.
  - Over 25 years of proven performance worldwide.
  - Highest quality.
  - Patented Smart Connect® feature.
  - Wide selection of sizes, types.
  - Meets/exceeds industry standards.
  - Guaranteed reliability.

Viega Hybrid Copper & PEX System

- Provides flexibility and versatility by combining copper and PEX tubing and fittings.

Centralized Parallel Water Distribution System

- A Viega parallel system provides the lowest pressure and temperature fluctuations in a plumbing system. Since each tubing line is dedicated to an individual fixture, interference between fixtures is eliminated. Additionally, specific fixtures can be supplied by smaller diameter tubing depending on the actual amount of water needed.
- For this type of installation, Viega offers the revolutionary MANABLOC parallel water distribution system, incorporating ViegaPEX tubing and Viega PureFlow PEX Press or PEX Crimp fittings. The Viega MANABLOC system provides a central location to control all plumbing lines and helps homeowners save energy costs and reduce water waste.

Viega MANABLOC parallel water distribution manifold

- Incorporates a system of PEX distribution lines dedicated to individual plumbing fixtures. Because dedicated tubing lines are plumbed specifically to each individual faucet, wait time for hot water is significantly decreased.
- Viega MANABLOCs arrive fully assembled and factory tested. They include individual quarter-turn port shutoff valves, which allow the end user complete control over the entire plumbing system from one central location. Fewer behind-the-wall fittings make it easy to install and less likely to leak. Flexible ViegaPEX tubing in 3/8" and 1/2" ensures optimal efficiency required to supply fixtures.

Energy & Water Conservation

- The choice to install 3/8" PEX tubing for low-demand fixtures instead of 1/2" will determine how much water an end user can save with a Viega MANABLOC system. In a length of 50 feet of PEX tubing, 3/8" PEX stores only .32 gallons of water (as opposed to 1/2" PEX tubing's .46 gallons). Storing less volume of water means less time is required to purge the line and deliver hot water twice as fast as with a 1/2" PEX line.
- Viega MANABLOC is a complete plumbing system that is easy to install and provides fast hot water delivery by decreasing energy costs and reducing water waste.

Viega MANABLOC system

Viega MANABLOC features and benefits

- Easy to install on each floor for residential applications
- Reduces wasted water
- Increased energy savings
- Delivers hot water fast
- Greater temperature and pressure balance during multiple fixture use
- Complete control of the plumbing system from a central location
- 1-1/4" internal reservoirs help maintain equal pressure during operation
- PLS plastic (polysulfone) resist aggressive water and corrosion
- 10 year limited warranty

SW Orientation

- In order to optimize solar energy (photovoltaic panels and solar radiation via passive windows during the winter) the PHMH will be oriented to the south.
- Exterior shades will be utilized in addition to 4-5’ Quad-Deck eaves to reduce the effects of solar radiation in the summer while capturing warmth and day-lighting in the winter through passive solar radiation.

Optimum Window Size

- The most appropriate size of windows for energy smart design depends on building orientation and the amount of thermal mass in the internal building materials.
- The total glass area is best kept between 20–25% of the total floor area for brick veneer houses and 22–30% for double-brick or ICF houses.

Window Design
& Shading Principles

The three main principles of energy smart window design and placement in the Northern Hemisphere are:

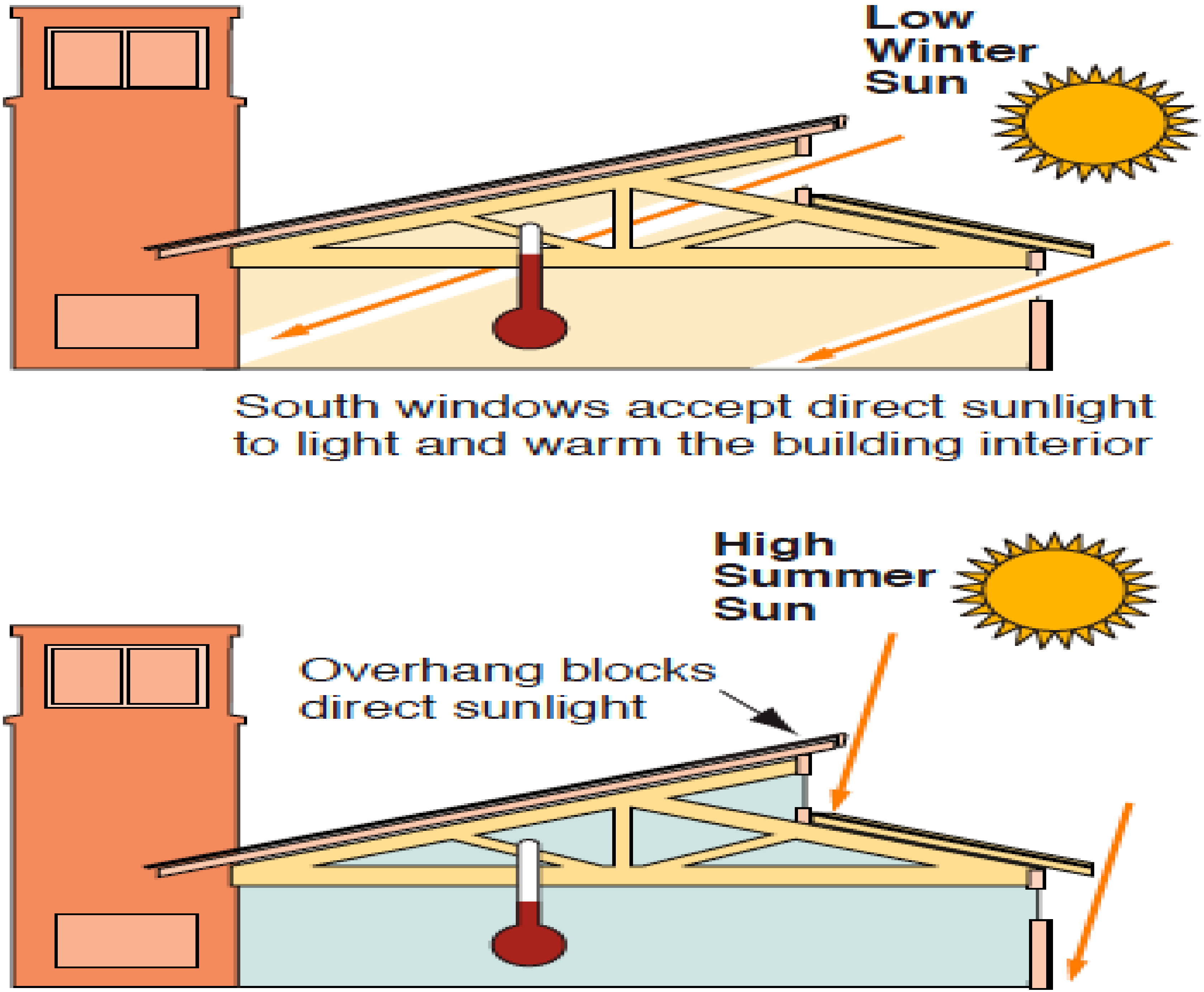
- Maximize winter heat gain by orientating windows to the south and sizing windows to suit the amount of thermal mass in the dwelling.
- Minimize winter heat loss through appropriate window sizing, together with double or triple glazing, storm windows, and/or close-fitting internal coverings such blinds and drapes with pelmets.
- Minimize summer heat gain by protecting windows with external shading devices, and through appropriate sizing and positioning of windows.

Eaves & Solar Control

- An overhang/eave, or some sort of solar control or solar shading, is a crucial element in passive solar design because it blocks the sun's heat energy when it is not desired.
- Because the sun travels different paths across the sky in the winter (low) and summer (high) time, eaves can be constructed to utilize and manipulate the heat energy from the sun.

Solar Radiation

- The following diagram shows how an overhang (or 4-5' eaves) can be constructed to allow the winter sun in, while it keeps the summer sun from hitting the dwelling.
- There is an additional outline showing the possibility of having sloped south wall with glazing (glass).
- While having sloped glass allows for the greater potential of winter heat energy storage from the sun, care must be taken to keep the building from overheating in the summertime.


Low
Winter
Sun
South windows accept direct sunlight
to light and warm the building interior
High
Summer
Sun
Overhang blocks
direct sunlight

Passive Solar Houses

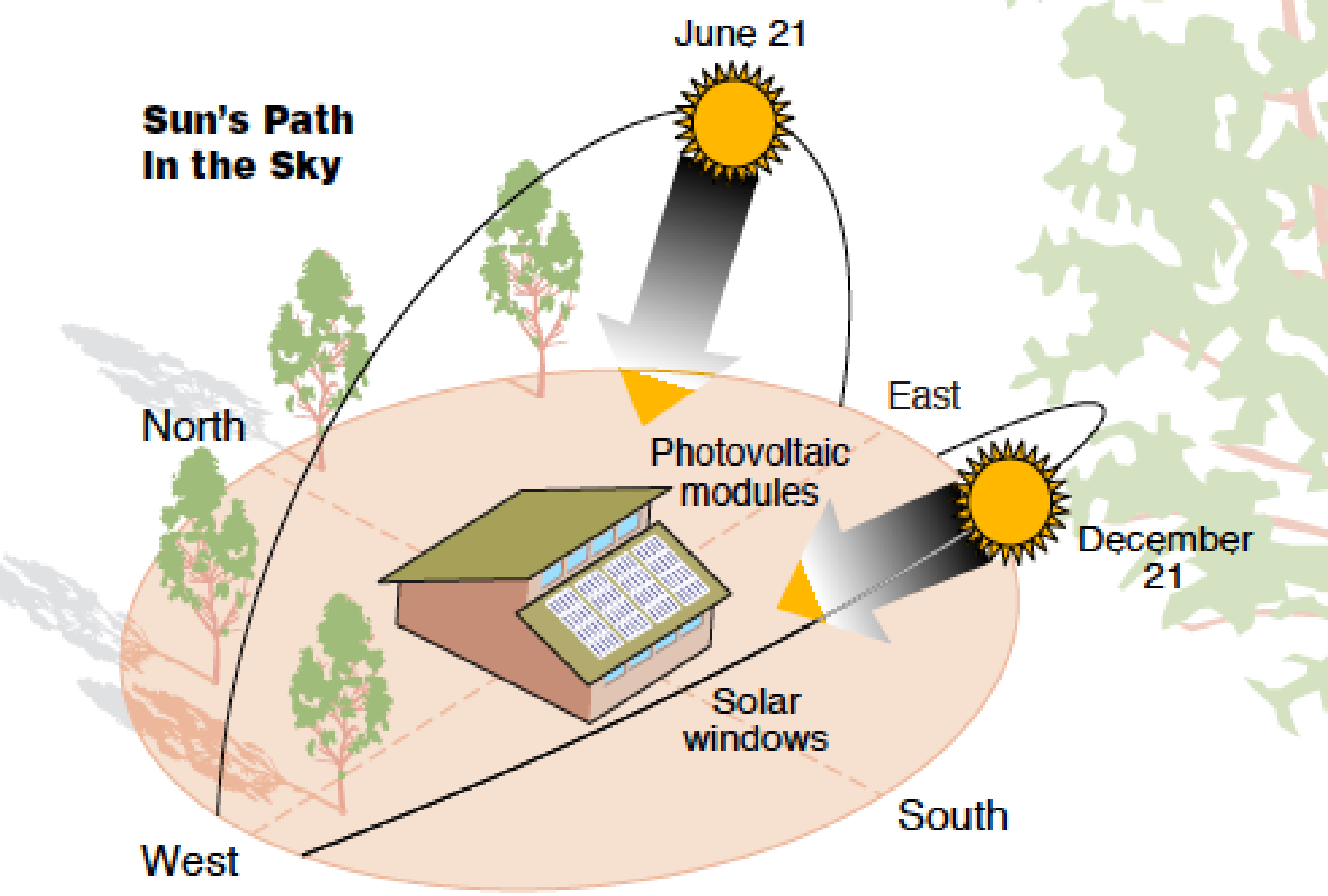
- In order to stay cool in the summer, passive solar houses rely on a system of shading (and/or an overhang such as eaves) to keep the building cool.
- Simply by building in this way, a house can reduce its heating and cooling costs by 85%.
- In the summer, as temperatures rise, a passive solar building uses its thermal mass to help keep the building cool. In order for this to happen, the summer sun is kept from reaching the thermal mass of the building.
- The concrete floors of the PHMH will aid in storing thermal energy by enhancing its thermal mass capacity.

Solar Orientation

- The summer sun's path aides in harboring passive solar energy by traveling high in the summer sky, thus a proper overhang or other type of system is needed to shade or cover the widow, in the summer so that the sun's heat energy is blocked or avoided when it is desired to have the building cooler than the outside temperature.
- A properly designed eave/overhang keeps the heat and energy from being absorbed into the house in the summer.

Summer & Winter Solstices

- As the Earth rotates around the sun on its annual cycle, it is tilted at an angle on its vertical axis.
- This impacts how the sun's rays strike various locations on Earth. The Earth is its most extreme tilt at the winter and summer solstices.
- The sun appears to rise in the east and it sets in the west. In actuality, the Earth is rotating on its axis and around the sun.


June 21
Sun's Path
In the Sky
North
East
Photovoltaic
modules
December
21
Solar
windows
South
West

The Earth's Orbit & Axis

- The seasonal position of the earth's orbit and turning axis affects how low or high the sun appears in relation to the horizon.
- In the winter, the sun is relatively low in the sky with its lowest arc through the sky on the winter solstice, on December 21st.
- In the summer, the sun travels a high path through the sky and is at its highest angle on the summer solstice, on June 21st.
- The equinox falls on the point between the solstices and indicates the arrival of spring or fall.

Utilizing Predictable Movements

- Passive solar design uses the predictable movements of the sun to best utilize its energy within the building's overall design both for heating and cooling purposes.
- Many passive solar buildings also include active solar aspects, such as photovoltaic panels

Indigenous Deciduous Shade Trees

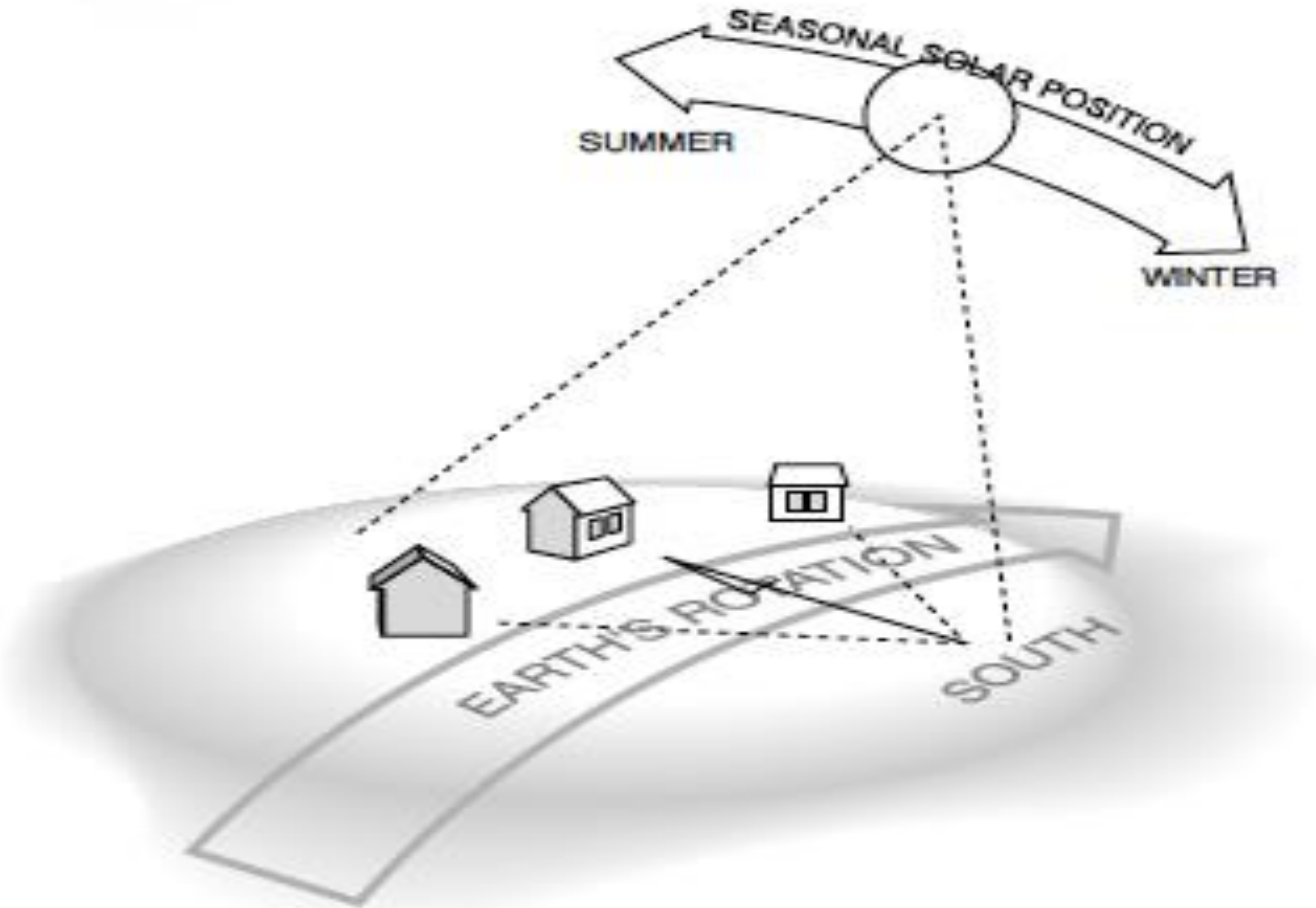
- In addition to using longer eaves/overhangs, and retractable window shades, incorporating deciduous shade trees into landscaping provides a natural way to provide shade in the summer, and passive solar radiation for the windows in the winter.
- Large indigenous shade trees will be utilized in the landscaping of the PHMH.

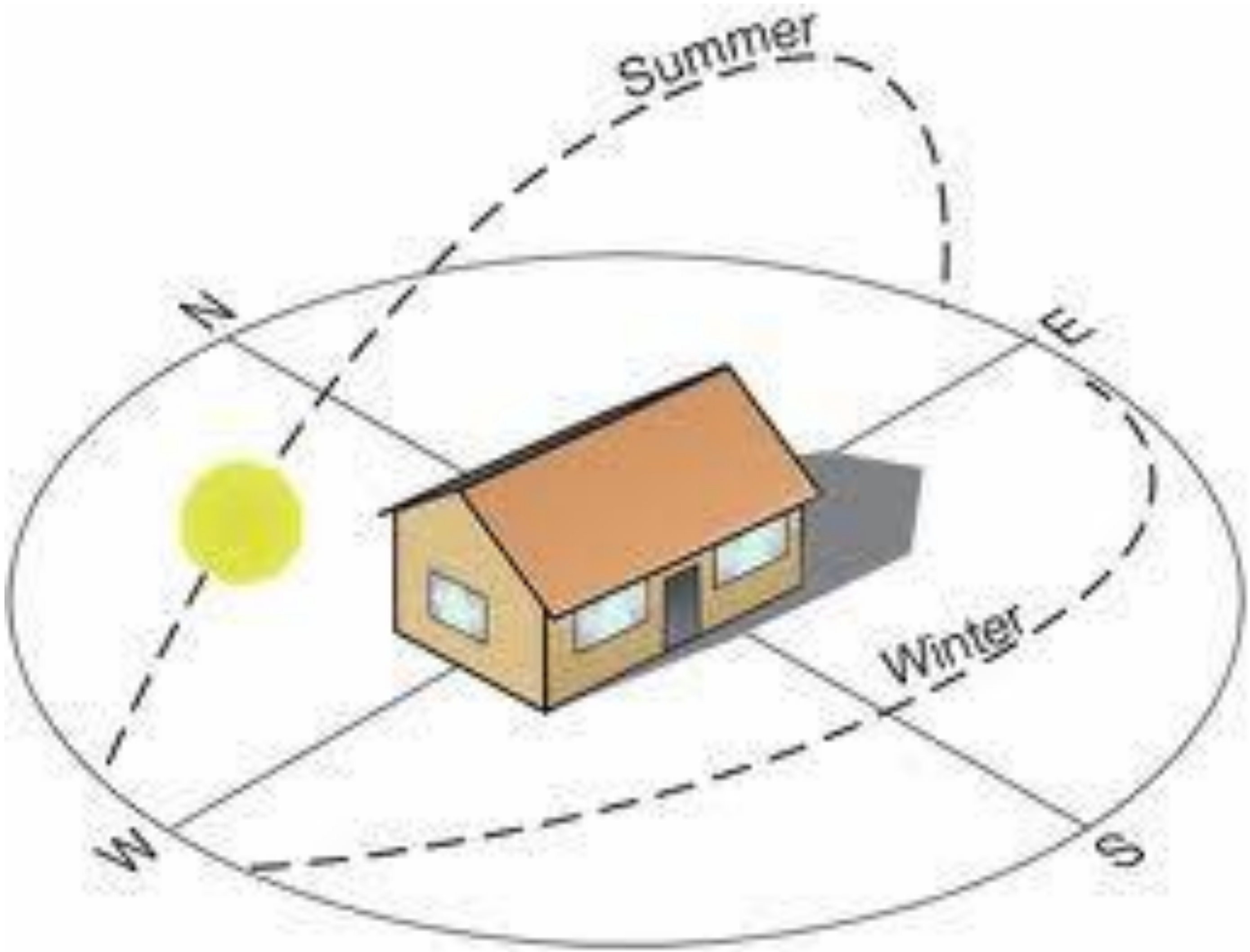
Building Orientation

- Because the sun rises in the east and sets in the west, the side of the building that is utilized for solar gain needs to be facing the south to take maximum advantage of the sun’s potential energy.
- If the building’s axis is located on the east-west direction with its longest dimension facing the south, more of the building is situated to absorb the sun’s heat energy.

Passive Solar Rectangular Shape

- Passive solar buildings are typically rectangular with the long side of the building facing south.
- The distance from the source of incoming heat (south) to where it is absorbed (typically a northern wall) should be minimized.
- The resulting shape is a rectangle.
- Efforts will be made to locate a lot that is ideal for orienting a rectangular PHMH facing south.


SEASONAL SOLAR POSITION
SUMMER
WINTER
EARTH'S ROTATION
SOUTH


Summer
N
E
Winter
W
S

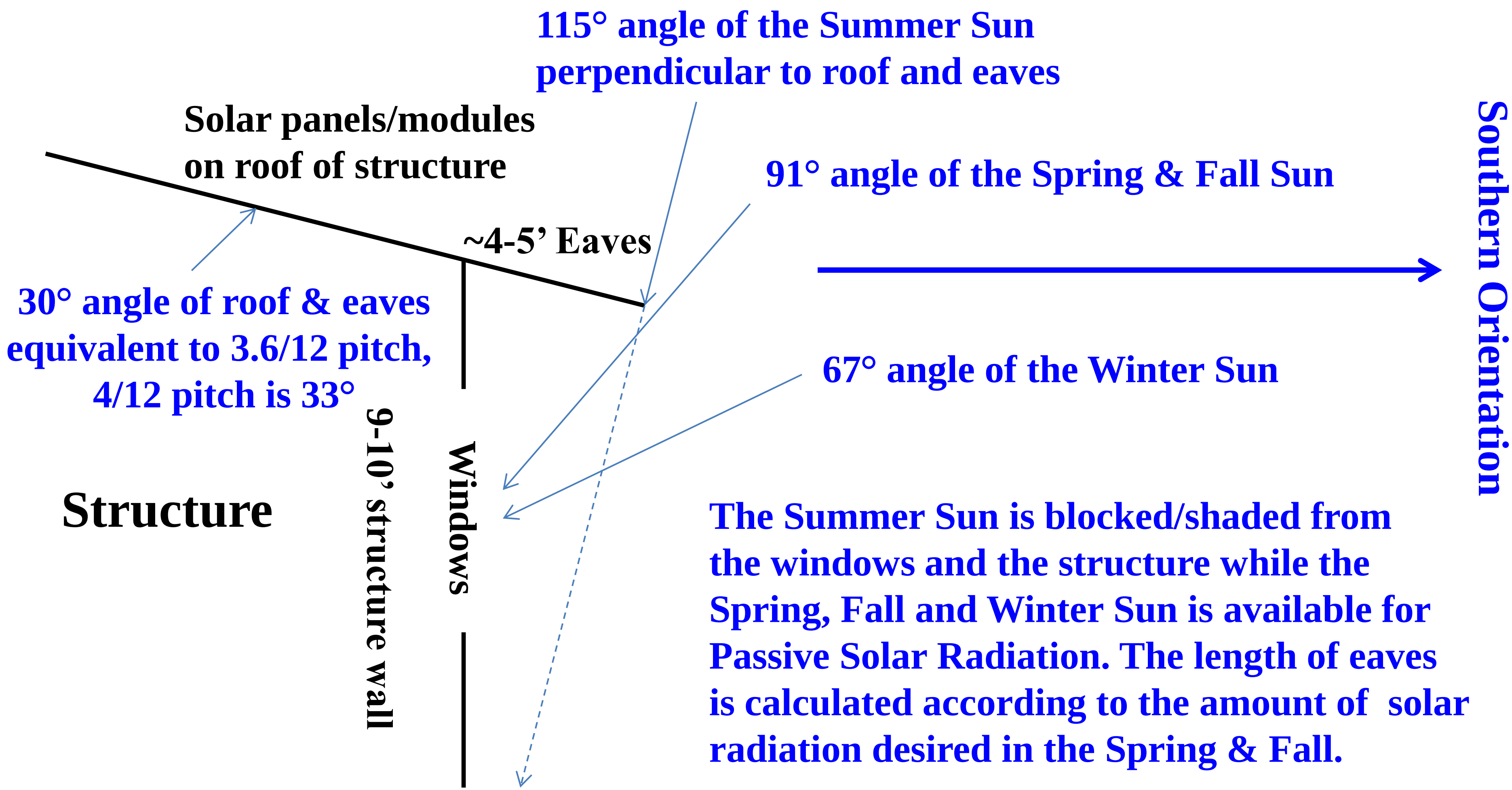
Calculating Overhang of Eaves for Homes in Boise, ID

Seasonal angle of the sun - degrees from vertical:

- On the 21st December, the sun will rise 67° east of due south and set 67° west of due south.
- On the 21st March/21st September, the sun will rise 91° east of due south and set 91° west of due south.
- On the 21st June, the sun will rise 115° east of due south and set 115° west of due south.

(This information can also be used to strategically adjust PV panels and thin film PV modules for maximizing efficiency of solar power systems, particularly through solar power arrays and solar tracking systems powered by an electric motor to provide up to 45% additional yields.)

Calculating Overhang of Eaves & Pitch of Roof for Homes in Boise, ID



South Facing Windows

- It is ideal to have the windows (solar glazing) within 5° of true south. However, windows that are within 15° of true south are said to function *almost* as well.
- As the degree difference from true south expands, the overall potential solar efficiency of the structure decreases.
- As a result, larger amounts of supplementary energy may be needed to heat the building in the winter.
- As the building's glass (glazing) faces more to the southwest, more energy may be needed for summer cooling.

Southern Solar Glazing

- Passive solar buildings typically have many windows facing the south
- Southern facing windows (southern solar glazing) are a vital component for a passive solar design and building.
- Because the southern side of the building is the side that will potentially receive sunlight throughout the day, most passive solar buildings will feature glass dominating the southern side.
- Southern facing glass allows the sun’s energy to be absorbed and distributed through the building’s thermal mass.

Glazing, Shades & Awnings

- Glazing is the fancy architectural word typically used for southern facing glass that has the capacity to transfer the sun's energy.
- Another benefit of having windows on the south side, is that it allows natural light to bathe the house throughout the day. This aspect will lower energy use throughout the PHMH since it minimizes the use of artificial light.
- While southern facing windows (glazing) are a necessary component of passive solar design, electric shades and retractable awnings will be used to insulate them in the winter after the sun goes down, and shade them in the summer.

Photovoltaic Panels & Wind Turbines

- Though relatively expensive to install, solar photovoltaic panels, wind turbines using wind cells, and net-metering for grid connected systems can provide an opportunity to achieve net-zero homes without investing in expensive battery storage systems.
- Similar to geothermal heat pump systems, there is currently a 30% tax credit available for installation of solar power systems.

Solar Panel Load & Costs

- The average home in the US uses about 1,000 kWh of electricity monthly.
- An all-electric home could increase this to 1,500 kWh of electricity monthly.
- Passive house design and energy conservation can reduce this to as little as 200-400kWh per month, or 6.7-13.3 kWh/day.
- This would require a 2-3 kW solar power system costing about $1.40/watt for equipment plus installation to achieve a net-zero home.

30% Mark-up & Installation Labor

- 30% equipment mark-up and installation would result in a total retail cost of $7,280-$10,920 for a 2-3 kW solar power system.
- At $3.64/watt, this is well under the $5/watt currently charged in the Boise area.

Energy Savings

- Not including the 30% tax credit, for a new home the portion of the monthly mortgage payment at 4.5% interest would range from $34.76-$52.13 for a 2-3 kW solar power system. With the 30% tax credit the payments would be $25.82-$38.73.
- For an all electric net-zero home using 80-90% less power than the average US home, the monthly energy savings at $0.0725/kWh would be about $56-$73 for passive solar on a grid-tied system plus the $2,184-$3,276 tax credit.
- 30% tax credits are also available for geothermal heat pump and radiant heating and cooling systems.

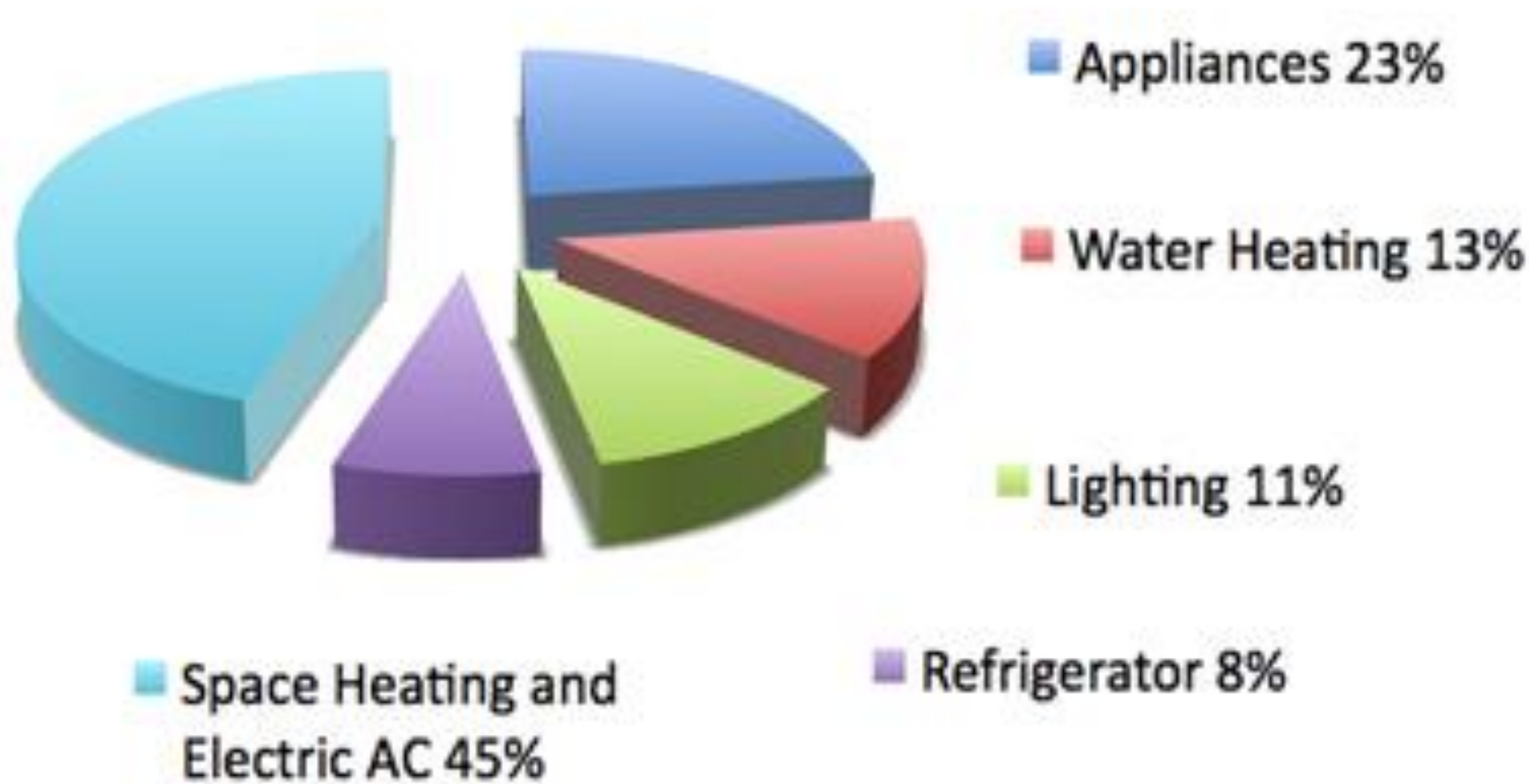
Depreciation & IRR

- For home offices and/or businesses that install solar power systems, they can depreciate the investment over a 5 year period.
- Based on a 5% mortgage rate, this can produce an Internal rate of return (IRR) of over 6.5% based on the current Idaho Power rate of $0.725/kWh.
- In addition, the mortgage interest or business loan interest can be deducted which would increase the IRR to over 13%.

Energy Conservation for Net-zero Homes

- In addition to going all electric on appliances, conservation of electricity is crucial for cost-effectiveness of net-zero homes.
- Keeping thermostat at a moderate temperature, using an ERV to exchange warm air with cool night air during the warm season, skipping the dry feature on a dishwasher, and reducing use of hot water, can all can have a significant effect on lowering energy demands.
- The key to limiting capital expenses for net-zero homes is in minimizing the size of the solar power supply.

Residential Power Consumption



HVAC, Hot Water & Lighting

- Geothermal heat pump systems for radiant heating, hot water, and forced AC can reduce energy consumption by over 60%.
- The water heater can be integrated with geothermal heat pump systems.
- LED light bulbs can virtually eliminate power consumption in comparison with conventional and flourescent light bulbs.

Reducing Total Energy Loads

- In addition to geothermal and hydronic heat pumps for heating, cooling and hot water, reducing energy consumption for appliances can dramatically reduce the total energy load for a home.
- This is critical in order to minimize the size of solar power systems in order to achieve Net-Zero homes.

Reducing Appliance Energy Consumption

- Appliances account for about 46% of a household's energy costs, with refrigeration, cooking, and laundry at the top of the list.
  - Integrate hot water needs with heat pump systems
  - Purchase energy efficient and smart appliances
  - Use appliances efficiently
  - Use LED light bulbs
  - Use LED TVs
  - Use lap-top computers or energy saver modes on desk-top computers and monitors

Appliance & Device Consumption in Watts

- Aquarium = 50–1210 Watts
- Clock radio = 10
- Coffee maker = 900–1200
- Clothes washer = 350–500
- Clothes dryer = 1800–5000
- Clothes iron = 1000–1800
- Dishwasher = 1200–2400 (the drying feature greatly increases energy consumption)

Appliance & Device Consumption cont.

- Dehumidifier = 785
- Electric blanket (*Single/Double*) = 60 / 100
- Fans

  Ceiling = 65–175
  Window = 55–250
  Furnace = 750
  Whole house = 240–750
- Hair dryer = 1200–1875
- Heater (*portable*) = 750–1500

Appliance & Device Consumption cont.

- Microwave oven = 750–1100
- Personal computer
  - CPU - awake / asleep = 120 / 30 or less
  - Monitor - awake / asleep = 150 / 30 or less
  - Laptop = 50
- Radio (*stereo*) = 70–400

Appliance & Device Consumption cont.

- Refrigerator (*frost-free, 16 cubic feet*) = 725
- Televisions (*color*)
  - 19" = 65–110
  - 27" = 113
  - 36" = 133
  - 53" - 61" Projection = 170
  - Flat screen = 120
  - LED flat screen = 100
  - Satellite Receivers & DVD recorders = 27,500
  - Cable Receivers & DVD recorders = 43,000

Appliance & Device Consumption cont.

- Toaster = 800–1400
- Toaster oven = 1225
- VCR/DVD = 17–21 / 20–25
- Vacuum cleaner = 1000–1440
- Water heater (*40 gallon*) = 4500–5500
- Water pump (*deep well*) = 250–1100
- Water bed (*with heater, no cover*) = 120–380

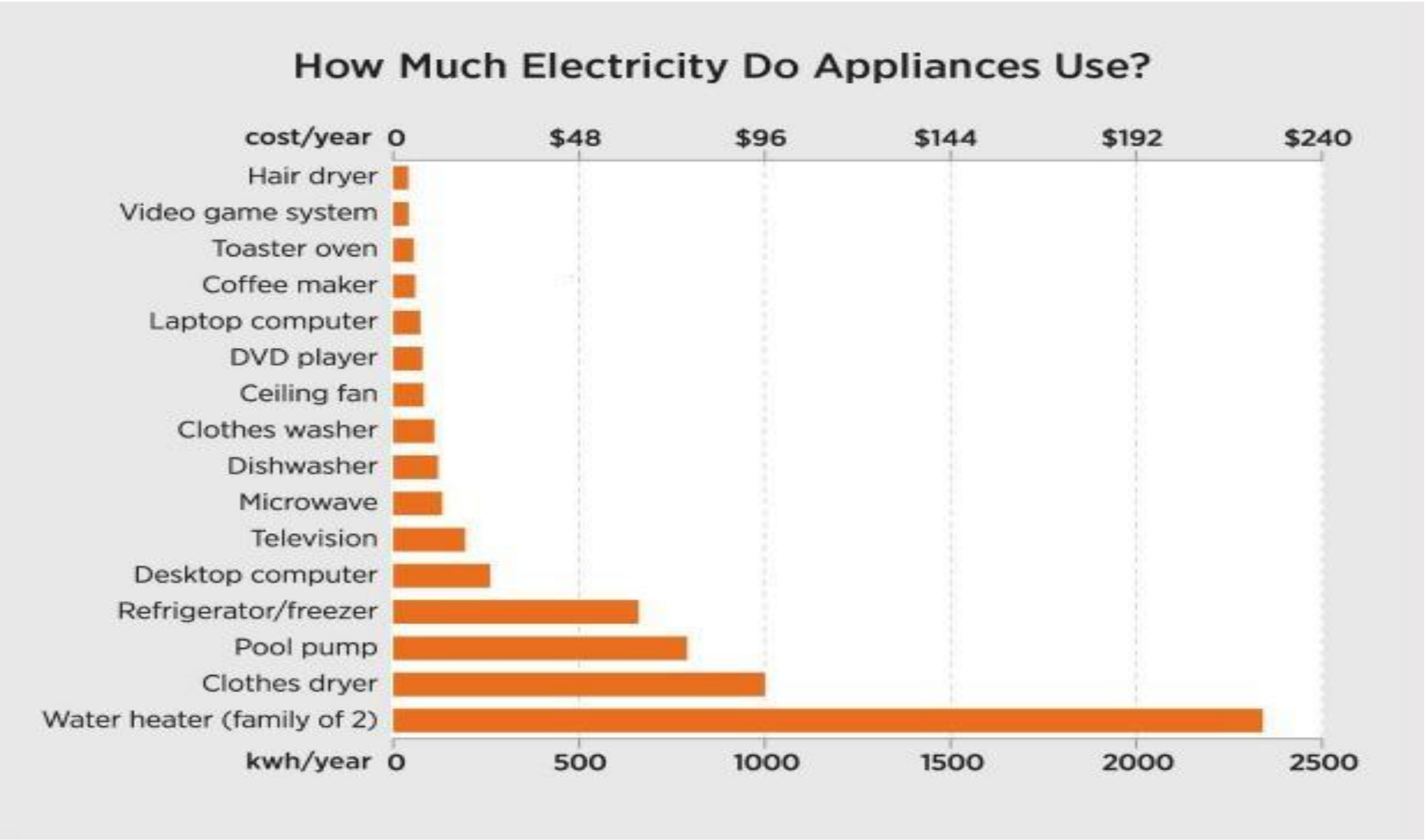
Refrigerator-Freezer Energy Tips

- Don't keep your refrigerator or freezer too cold. Recommended temperatures are 37°-40°F for the fresh food compartment and 5° F for the freezer section. If you have a separate freezer for long-term storage, it should be kept at 0° F.
- Check the refrigerator temperature by placing an appliance thermometer in a glass of water in the center of the refrigerator. Read it after 24 hours. Check the freezer temperature by placing a thermometer between frozen packages. Read it after 24 hours.

Refrigerator-Freezer Energy Tips cont.

- Make sure your refrigerator door seals are airtight. Test them by closing the door over a piece of paper or a dollar bill so it is half in and half out of the refrigerator. If you can pull the paper or bill out easily, the latch may need adjustment, the seal may need replacing, or you may consider buying a new unit.
- Cover liquids and wrap foods stored in the refrigerator. Uncovered foods release moisture and make the compressor work harder.
- Regularly defrost manual-defrost freezers and refrigerators; frost buildup decreases the energy efficiency of the unit. Don't allow frost to build up more than one-quarter of an inch.

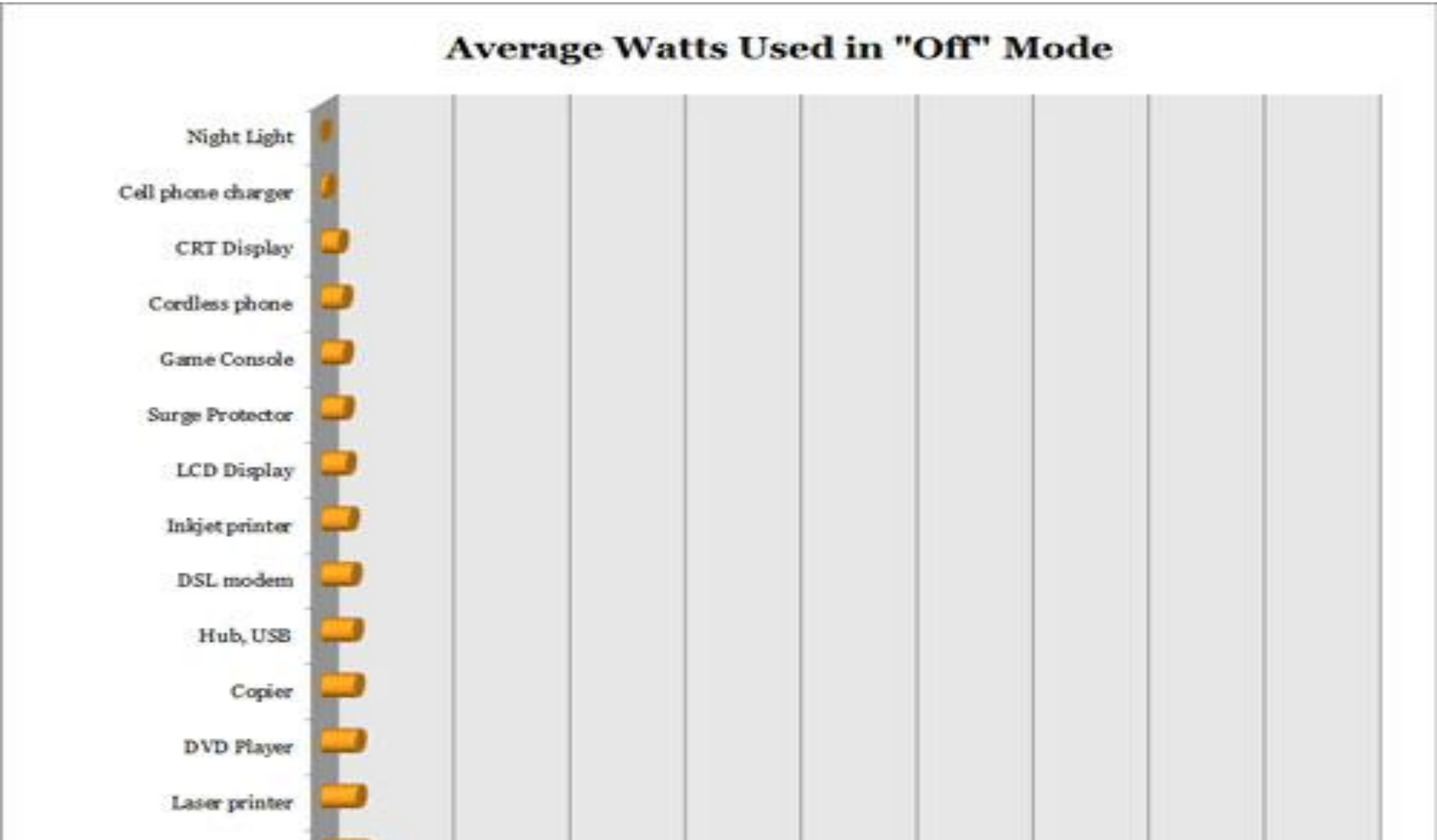
Strategy for Reducing Energy Load



Energy Standby or Off Mode

- An alarmingly large number of electrical products cannot be truly turned off without being unplugged. These devices draw standby power 24 hr./day whether on or off.
- Standby power is consumed by power supplies (the black cubes – sometimes called “vampires” – connecting AC to DC), the circuits and sensors needed to receive a remote signal, soft key pads and displays including misc. LED status lights.
- Standby power can also be used by circuits that continue to be energized even when the device is “off”.

Average Watts used in “Off” Mode



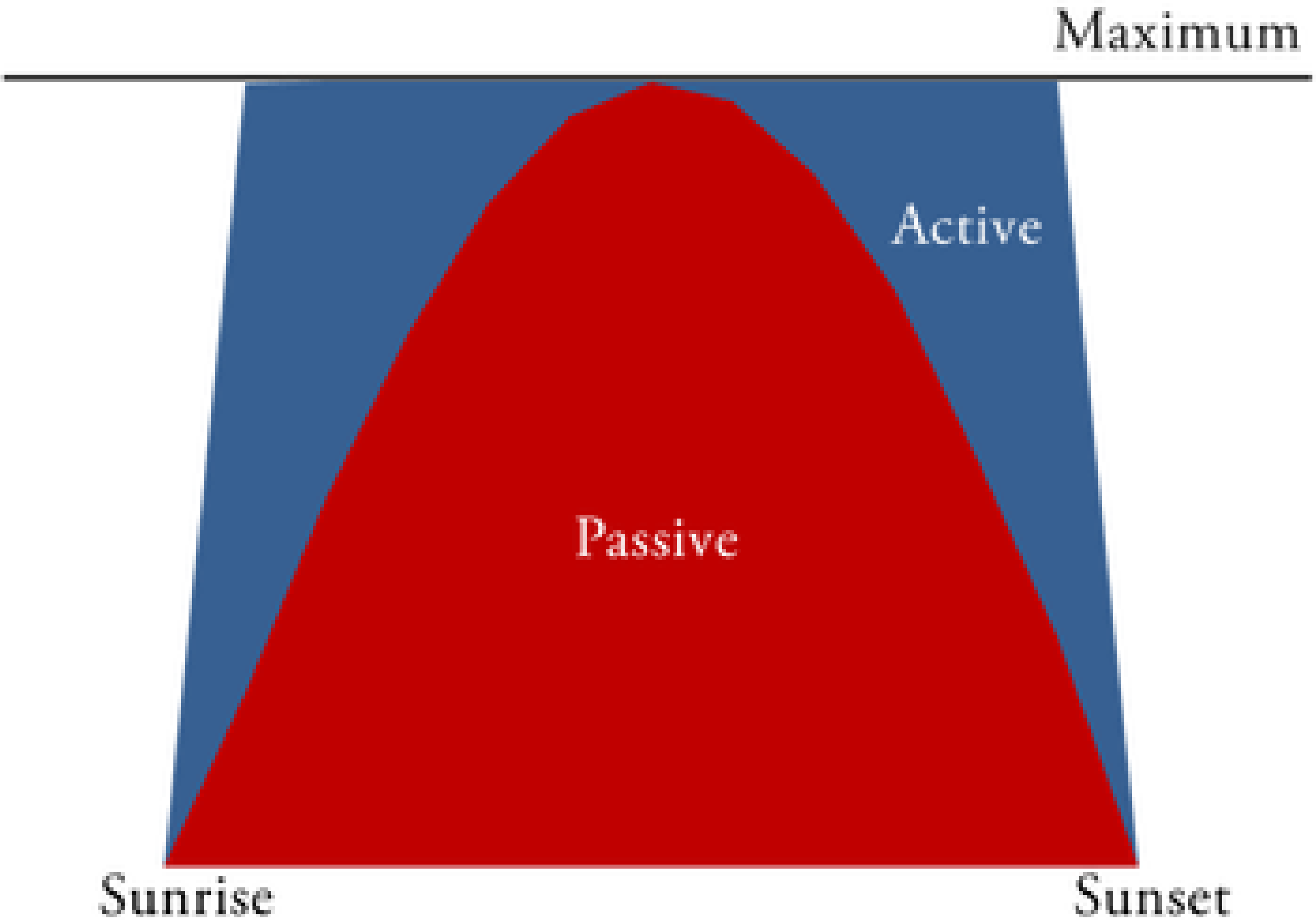
Standby Strategy

- A typical home can have forty devices drawing standby power which can comprise up to 10% of the average homeowner's electric bill.
- Use a switchable power strip to disconnect power from clusters of computer or video products.
- Buy low standby products, e.g., search the Energy Star ratings for particular electronic devices.

Active vs. Passive Solar Power Systems

- A fixed, **passive** solar system captures less of the sun’s rays than an **active** dual-axis tracking system.
- When the sun is rising or setting it only shines a small amount of light on the fixed panel in the morning and the evening times.
- A two axis solar tracker points the panels in the optimal direction all day, everyday.

Active Solar Increase



Maximizing Solar Power

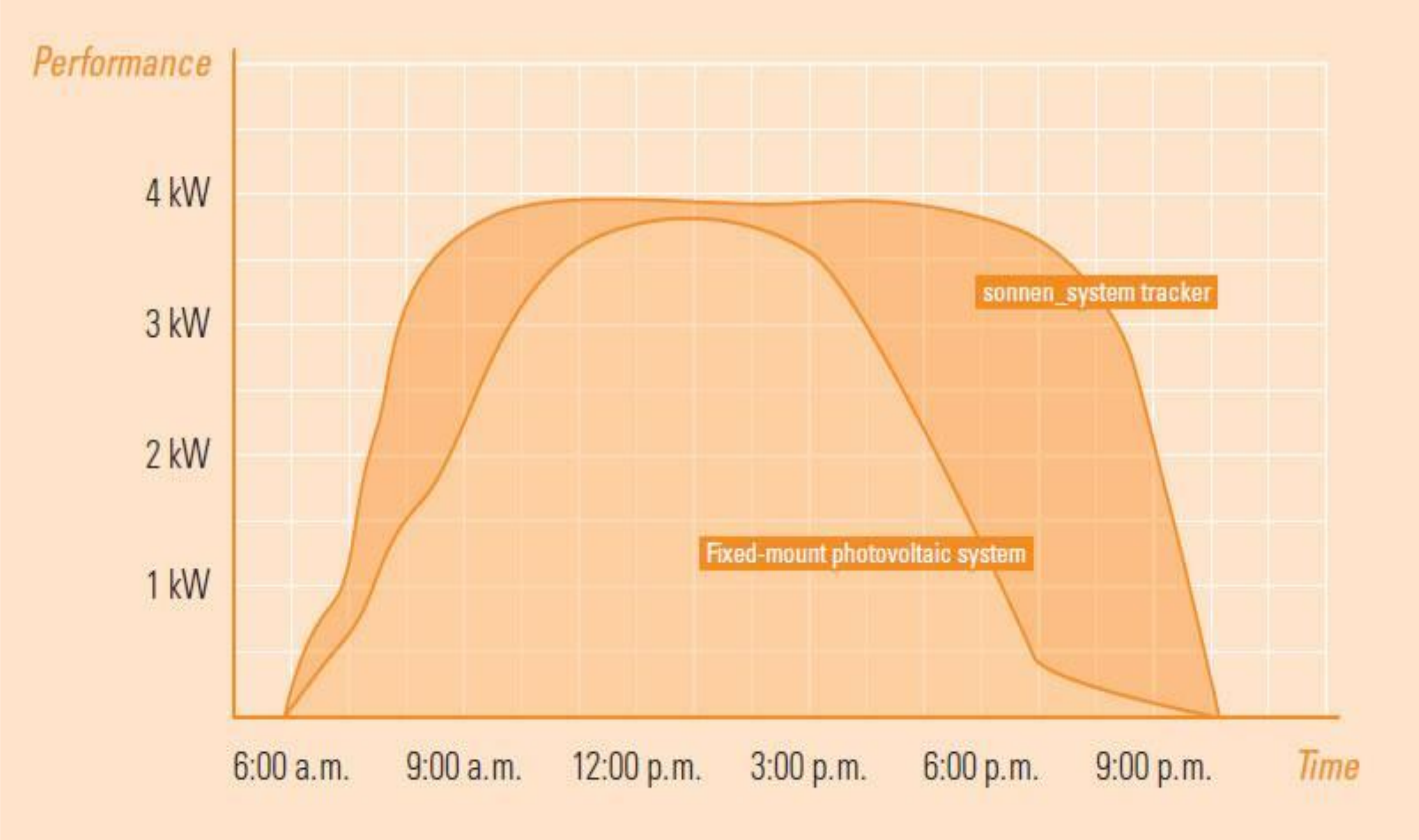
- By tracking over the course of an average day, this translates to about 40% more power from the same amount of panels as a fixed panel system and up to 50% or more during the summer days.
- The graph above shows how much energy is being generated throughout an average day by **Active Solar** (blue) and a passive system (red).

Dual-Axis Solar Tracking System

Up to 45% more Power than Fixed Solar Panels

Sonnen Systems 19-60 m² Solar Tracking Systems
German technology distributed by www.civicsolar.com in the US

Solar Tracker Performance



NREL's Solar Redbook

- 30 years of data collection by the National Renewable Energy Lab (NREL) reveals that on average, Boise, ID has 7.1 hr. ($kWh/m^2/day$) of sun days.
- This is based on solar radiation for a dual Axis tracker with flat-plate collectors ($kWh/m^2/day$) +/- 9% (in contrast to fixed single Axis tilt of 4.5 hr. sun days, and 6.3 hr. sun days for a single Axis tracker).

NREL's PVWatts Calculator

- However, according to NREL's PVWatts online calculator average annual production (due to various inefficiencies) for active dual axis PV technologies is only 1.928 kWh/m^2/day; and for passive single axis tilt it is only 1.365 kWh/m^2/day (considerable room for improvement as PV technology is currently only 18% efficient).
- Sun day hours are 15%-45% less for ground mounted and roof mounted fixed PV panel systems.

Sonnen Systems Tracker Technology

- Biaxial tracking system for photovoltaic installations
- Astronomical control based on local coordinates
- Centralized monitoring via Internet
- Comprehensive safety concept: the safeguard
- Building integration feasible
- Additional yield up to 45% compared to fixed-mount installations
- Track-back function to prevent cross-shading
- 20-year warranty (depending on service agreement)
- Suitable for all panel brands

Solar Tracking Systems

- Stand alone structures with concrete footings or can be mounted on buildings (ICF structures)
- 19-60 m^2 (4.75-15 kW) solar arrays
- Maximum installation height – 66'
- Weight – 1480 lb.
- Angular range – azimuth 270°/elevation 70°
- Angular accuracy by 0.1° - 0.25°
- Wind alert system operates at wind speed ≥ 29 mph
- Monitoring system for the entire plant via SMA Sunny WebBox

Remote Monitoring via track_app™

- track_app™ is a truly portable solution for monitoring and operating sonnen_system trackers and SMA inverters remotely.
- Available for both iPhone and iPad, track_app™ is a simple and intuitive application with an integrated display of real-time tracking performance, enabling data system operators to be in complete control no matter their location.

"track_app™" Mobile Technology

Active Solar via Dual Axis Tracker Return on Investment

- US companies such as Array Technologies' Wattsun Solar Trackers and All Earth Renewables provide similar solar tracking systems ranging from 1.5-7 kW for about $4.50/kW installed (~$0.85-$1/watt for PV panels).
- This is similar in price to what some fixed solar panels are currently being installed for including labor.
- Fixed solar panels and installation kits can be purchased from wholesale distributors for about $0.70/watt and $1.40/watt respectively.
- Based on these prices, the 35-45% increase in power production could provide an immediate ROI in comparison with less efficient fixed or passive PV panels.

All Earth Renewables
Solar Tracking System

Electricity Demands for an all Electric Net-Zero Home

- For the average home using about 12,000 kWh (~18000 kWh for all electric) annually, a passive house can reduce that to about 1,500-3,000 kWh annually for all electric appliances including stove/oven, dryer, and water heater.
- That equates to a total energy load of 4.1-8.2 kWh/day for net-zero homes using passive house construction.

Calculating Capacity of a Solar Power System

- The capacity of solar power systems is based on the amount of peak energy that can be produced per hour of sunlight.
- Thus, a 1 kW solar power system is capable of producing 1 kW per hour of sun light.
- Allowing for inefficiencies in the PV panels, hot environments, and inverters, a conservative 4 hour “sun day” is about what can be expected on average in Boise, ID for a passive system.

Active Solar Power System

- On average, an active solar power system will produce 30-45% more power than a passive solar power system.
- However, for conservative purposes, we will use a 1.9 hour sun day for calculating power capacity for both active and passive systems in Boise, ID.
- Hence, a 4.1-8.2 kWh energy load would require a 2-4kW solar tracker.
- Larger than normal homes with all electric appliances could require a 4-6kW system.

Wattsun Solar Trackers
AZ-125 & AZ-225 Azimuth Models

- 4-6 (250 watt) panel (1-1.5 kW system) solar tracker - $2,284 (e.g., about $1.52-$2.28/watt or $0.11-0.13/kWh for 1.9-2.85 kWh/day without panels over a 25 year period not including maintenance)
- 9 panel (2.25 kW system) solar tracker - $4,200 (e.g., about $1.86/watt or $0.11/kWh for 4.275 kWh/day without panels, etc.)
- 12 panel (3 kW system) solar tracker - $5,200 (e.g., about $1.73/watt or $0.10/kWh for 5.7 kWh/day without panels, etc.)

Structural & Mechanical Features/Specifications

Tracking Type	Dual Axis Azimuth/Elevation AZ-125 Dual Axis Optional
Azimuth Range of Motion	270°
Elevation Tilt Angle	5° to 75°
Motor Power Consumption, Azimuth	Daily watt-hours From 10 w-h DC to 20 w-h DC
Drive Type	Gear Drive
Elevation Motor Type	Heavy Duty Linear Actuator
Motor Type	1/15 HP, 24 VDC Nominal
East-West/North-South Dimensions Array	Site/module specific
Height	Site/module specific
Modules Supported	Most commercially available
Module Configuration	Landscape/ module specific
Module Attachment	Proprietary extrusion/ std. mounting bolts
Materials	High-strength galvanized steel & anodized aluminum
Allowable Wind Load	IBC 90 MPH, 3-second gust exposure C

Additional Features & Specifications

ELECTRONIC CONTROLLER FEATURES/SPECIFICATIONS	
Solar Tracking Method	Closed Loop Optical
Control Electronics	Proprietary
Tracking Accuracy	+ or – 2° standard, field adjustable
INSTALLATION, OPERATION & MAINTENANCE	
Gear Drives	Grease every 1 year
GENERAL	
Energy Gain vs. Fixed-Tilt	Up to 40%, site specific
Warranty	2 years parts only, 5 year extended available
Made in the USA	Yes

Azimuth AZ-125/AZ-225 Wattsun Solar Trackers

Wattsun Solar Trackers
Division of Array Technologies

- Wattsun is currently in the process of coming out with a 20 panel (5 kW) single axis solar tracker - $??
- Though this single axis tracker will be 6-7% less efficient than a dual axis tracker, it will also be less expensive.
- Most commercial solar power fields use only single axis technology in their solar trackers.
- Solar trackers use very low horsepower (1/15) motors that are very efficient to operate and economical to maintain.

PV Mono/Poly Crystalline Panels

- 250-300 watt panels can currently be purchased wholesale from www.RENVU.com for about \$0.68/watt and up.
- This is about \$0.20-\$0.30/watt lower, e.g., about 20-30% less than purchasing panels directly through solar tracker manufacturers.
- This allows for providing solar tracking and racking systems for about \$2.20-\$3.38/watt, or \$0.10-0.13/kWh not including installation costs and 30% mark-up for materials and equipment, all of which qualify for the 30% tax credit.

Labor & Installation

- $2.20-$3.38/watt, or $0.10-$0.13/kWh not including installation and 30% mark-up for materials and equipment would amount to about $4.40-$6.76/watt.
- However, the 30% tax credit for solar power systems would proportionately reduce the amount paid per watt.

Larger Solar Trackers

- AllSun Trackers by All Earth Renewables begin at 5kW, are more sturdy than Wattsun trackers, and are guided by GPS which makes them more reliable than sun guided systems.
- Sonnen Systems begin at about 7kW and are considerably smaller than the 66’ commercial models for use in the residential market.

All Electric Net-Zero Homes

- For an all-electric passive home (e.g., stove/oven, dryer, and water heater), the ROI could be less than 3 years.
- For a new home in which the solar tracker is financed, the energy savings should provide an immediate ROI in comparison with the amortized portion of the mortgage used to pay for the active solar power system.

Average Size Solar Tracking System for Passive Homes

- The average size passive home would use less than 4-8 kWh/day.
- So in most cases the average sized passive home would require only a 1-2kW solar tracker and racking system.
- For a 30 year mortgage at 5% interest, the portion of the monthly mortgage payment for installing a 1-2kW solar tracking system (about $6,000-$12,000) would be only $33-$65.

Immediate Cash Flow for Net-Zero Homes

- The cost of electricity in Idaho is currently ~$0.072/kWh and going up each year (since Idaho Power built a new 5 MW natural gas power plant that they are paying for and passing the cost onto consumers).
- Hence, the current monthly power bill for the average home is $72. Thus, this scenario reflects an immediate cash flow from day one for net-zero homes using passive house construction.

All-Electric Appliances

- For all electric appliances, the average kWh could be 50% higher, e.g., 18,000 kWh annually.
- For a 90% increase in energy efficiency for a passive house, that would result in increasing the size of the solar tracker and racking system from 1.5kW up to 3kW.
- However, the monthly power bill would increase to $108, providing a savings of around $70/month.

Economics of Active vs. Passive Solar Power Systems

- The 30-45% increase in yield for a solar tracking system would provide an immediate cash flow for new home construction (in which the 20% increase in cost for the solar tracking system is amortized over a thirty year period via a mortgage).

Structural Mounting

- For the residential market, solar tracking systems could be installed on the roofs of ICF structures.
- ICF roofs and mounting area could be engineered to accommodate a safe and secure roof mount for new construction.
- This could alleviate concerns for liability and provide safe access for annual maintenance, e.g., lubricating the gears.
- This could substantially expand the potential market for residential applications.

What is Net Metering?

- Net metering is a program that allows customers to generate power on their property and connect it to a utility's power system.
- The electric meter "spins" backwards, providing a credit for energy produced against charges for energy used.
- Systems connected to the grid are referred to as "interconnected" or grid connected power systems.

How does Net Metering work?

- For residential and small commercial customers, the renewable source of generation is connected on the customer’s side of the electric meter. Energy generated is consumed inside the residence first and any
- excess would flow from the meter to the power lines. At the end of the month, if consumption outpaces production, a monthly power bill is sent to the customer for the energy consumed.
- If production outpaces consumption, a credit appears on the bill.

Buying & Selling Power

- How much would I be paid for my power and how much would I have to pay for the power I use?
- Residential and small commercial customers are paid for excess generation at the same base retail rate that they are charged for electricity.
- Other Idaho Power customer classes are paid under a different, calculated rate structure.

Building Net-Zero Homes

- In 2011, the average annual electricity consumption for a US residential utility customer was 11,280 kWh, an average of 940 kWh per month.
- By reducing the power load by 90%, a solar photovoltaic system producing only 100-200 kWh per month (~1-2 kW system) may be sufficient for conversion of a passive house to a net-zero home via net-metering.

Idaho Power Fees for Net-Metering

- Monthly fees for participating in the net-metering program are $5/month.
- Credits are issued for overage to discourage over-producing.
- There is currently no limit to the volume of power generation produced by the residential market.

Solar Photovoltaic Power Systems

- 8 Talesun 250 watt Solar Panels (660M) providing 2kW power for $1.15 /watt, e.g., $2300 on eBay (for solar panels only), or $0.68/watt via buying overstock volume by the pallet from www.renvu.com.
- 2kW Solar Kit Canadian 250P, SMA inverters, Mounting, for $2.44/watt, e.g., $4880
- Grape Solar GS-2300-KIT Residential 2,300 Watt Grid-Tied Solar Power System Kit for $4/watt, e.g., $9,238 on Amazon (also available via Costco, Home Depot and Lowes.
- Pricing of panels and installation kits continue to come down, making solar PV power systems more and more affordable, particularly via tax credits.

Thin Film PV Module Technology

- Also called laminate PV material, provide an economic alternative to conventional PV (mono or poly crystalline silicon) panel technology.
- Lower cost and higher performance in hot sunny environments is available.
- Installation can be less labor intensive since racking systems are not required.
- Available from www.civicsolar.com
- Three primary types:
  - amorphous silicon (a-Si)
  - cadmium telluride (CdTe)
  - copper indium gallium selenide (CIGS)

Comparisons of Traditional Advantages & Disadvantages of Thin Film PV Technologies

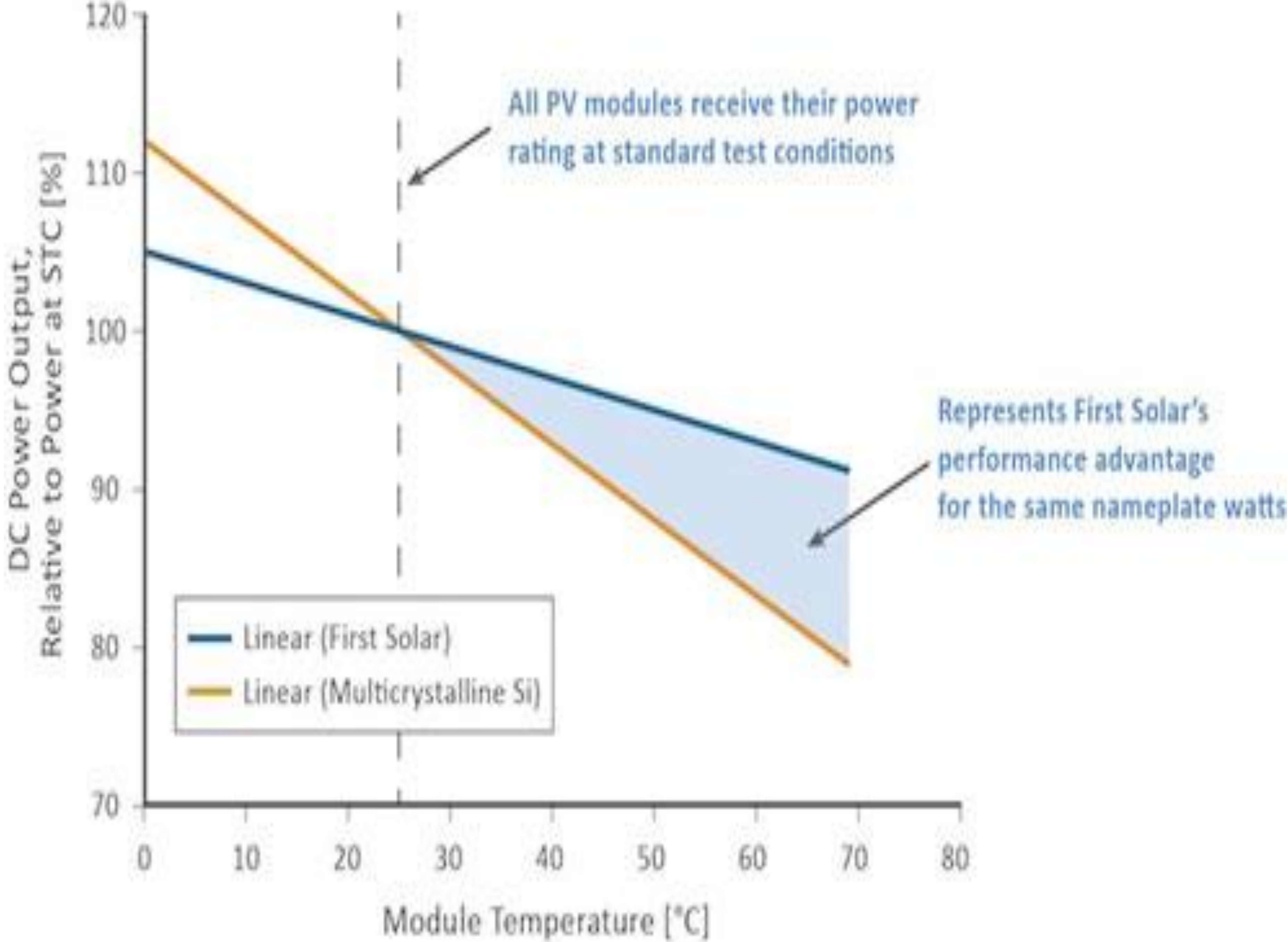
Technology	Maximum Demonstrated Efficiency for small cells*	Advantages	Disadvantages
a-Si	12.2%	Mature manufacturing technology	Low efficiency High equipment costs
CdTe	16.5%	Low-cost manufacturing	Medium efficiency Rigid glass substrate
CIGS	19.9%	High efficiency Glass or flexible substrates	Film uniformity challenge on large substrates Costly traditional processes

Advanced Thin Film PV Modules

- Wholesale cost is ~$0.75/watt for thin film cadmium telluride (CdTe) PV technology, about half the retail cost of conventional PV (crystalline silicon) panel technology.
- Thin film modules are the foundation to the world's most advanced PV power plants, particularly in sunny and hot climates.
- Smallest carbon footprint and fastest energy payback time of any PV system.

Superior Performance

- With a proven performance advantage over crystalline silicon technologies, First Solar’s world-record holding CdTe thin film solar modules deliver higher energy yields at elevated temperatures due to a lower temperature coefficient.
- Beyond temperatures of 25°C, First Solar modules produce more energy for the same nameplate watts and provide stronger plant performance in high temperature climates than conventional PV panels.


120
110
100
90
80
70
DC Power Output,
Relative to Power at STC [%]
0
10
20
30
40
50
60
70
80
Module Temperature [°C]
All PV modules receive their power rating at standard test conditions
Represents First Solar's performance advantage for the same nameplate watts
Linear (First Solar)
Linear (Multicrystalline Si)


Thin Film Photovoltaic (PV)
- On the roof to make electricity
Solar Panel
- To produce back up electricity for the pumps
Solar Evacuated Tubes
- To heat the house and supply domestic hot water

Proven Technology

- First Solar modules have been verified by independent engineers and certified to international performance and safety standards by third party laboratories around the world, including installations with NREL for over 16 years.
- First Solar modules are proven and backed by a limited 25-year power output warranty and a limited 10-year materials and workmanship warranty.

Certified for Reliability and Safety

- Certified for performance and safety according to IEC 61646, IEC 61730, and IEC 61701 (salt mist corrosion)
- Regionally certified to UL (North America), CEC (Australia), Golden Sun (China), and MCS (UK) standards
- Manufacturing certified to ISO 9001:2008 (quality), ISO 14001:2004 (environmental) and OHSAS 18001:2007 (occupational, health and safety) standards

Sun Power Energy Systems

- Alternatively, a solar powered system can be purchased directly from the manufacturer, e.g., SunPower to provide the highest energy efficiency (21.5%) in the industry.
- The system comes with an industry leading 25 year warranty and no down payment leases are available.
- There is currently an opportunity to become a distributor/dealer in the Boise, ID area.

Net-Zero Homes

- By reducing the energy load via Passive House design, grid-connected solar power systems for net-zero homes are affordable.
- The power provided by the net-metering system eliminates the need for charging batteries.
- For provision of backup power a natural gas or liquid fuel powered generator can be installed.

Additional Solar Energy System Benefits

- New research by the U.S. Department of Energy’s Lawrence Berkeley National Laboratory finds that installing a residential solar energy system increases a home’s value by an average of $17,000 in California.
- Though the average increase in value may be considerably less in other states, there is no doubt that it adds value to almost any home.

Smart Home Control Systems

- From geothermal and solar energy sources to forced-air and radiant distribution systems, and combinations thereof, the options for achieving indoor comfort are increasingly complex and the targets for efficiency increasingly rigorous.
- Smart Controls system, designed for residential and mid-range commercial buildings, enables intelligent integration and optimization of a building’s appliances and HVAC system components.

Internet Accessibility

- Smart Control Systems can be accessed with any Internet-accessible device. This allows for making adjustments to your indoor climate from practically any location in the world. Even if you're not on-site, you can still be sure your HVAC systems are optimized for maximum energy efficiency and comfort.
- While the appeal of the Smart Control system to homeowners may be primarily its convenience, for a commercial building where a few optimization adjustments can add thousands to the bottom line, Smart Controls is smart business.

Working 24/7 to Optimize HVAC System Performance

- Smart Control systems are programmed to react to changes in your home/building’s environment, so it is working 24/7 to optimize HVAC system performance and indoor comfort.
- From your smart phone or any other Internet-enabled device, you also have access to monitor and update system settings, making system control even smarter.
- Allows you to set individual temperatures for each controlled zone.
- Stores and maintains your settings in a database accessible from anywhere in the world via the web.
- Optimizes and manages the combined use of heating, cooling and ventilation systems to achieve comfort with the lowest possible energy use.

Working 24/7 to Optimize HVAC System Performance cont.

- Interfaces with weather services, automatically adjusting settings in advance of changing weather conditions.
- Constantly monitors the health and functioning of the HVAC system and reports problems immediately.
- Permits you to define specific on/off events in your settings, so operation of water heater, forced-air and radiant systems can be coordinated to ensure the highest level of efficiency.
- Makes sophisticated controls technology user friendly with an easy-to-use, point-and-click interface accessed through a standard web browser.
- Allows service contractors to access your system and efficiently diagnose potential issues before arriving at your site.

PowerWise Complete Building Intelligence System

- insense™ Sensor Network
- inDAC™ Data Acquisition & Control
- eMonitor Gateway
- Circuit-Level Electrical Monitoring
- inServe™ Server w/Advanced Analytics
- inView Passive House Monitoring (recommended by PHIUS)

Sensors & Flow Meters

- CO_2 Multi Sensor
- PowerWise Multi Sensor
- Relative Humidity – Temp. Sensor
- Stainless Steel Temp. Sensor
- Gas Flow Meter
- Analog Flow Meter
- Pulse Flow Meter for Water or Glycol
- Water Monitoring
- Pyranometer

inDAC Sensor Data Acquisition & Control Module

- Reveals performance and ROI of equipment including how heating, cooling, and ventilation systems impact comfort conditions within a building. Allows for accurately sizing HVAC systems by assessing how they perform.
- The inDAC system reads sensor data from sensors on 1-Wire networks, including pulse counters, and analog output from equipment like Heat Recovery Ventilators, Energy Recovery Ventilators, Fan Coil Units, etc. Monitor temperature, air flow, water/propane flow, humidity, air quality, and more.
- The inDAC works with the eMonitor Gateway to send information to the Internet.

inDAC Sensor Data Acquisition & Control Module cont.

inDAC Overview

- The inDAC is a microcontroller designed for monitoring and controlling building systems. The controller features a MODBUS RTU communication protocol for connection to a MODBUS enabled gateway device.
- Multiple inDAC units can be placed in series via MODBUS to expand analog and digital inputs/outputs for increased monitoring and control.

inDAC Applications

- Solar thermal system monitoring
- Ground source heat pump system monitoring
- Domestic hot water system monitoring
- ERV & HRV characterizations
- Rainwater collection systems

eMonitor Gateway

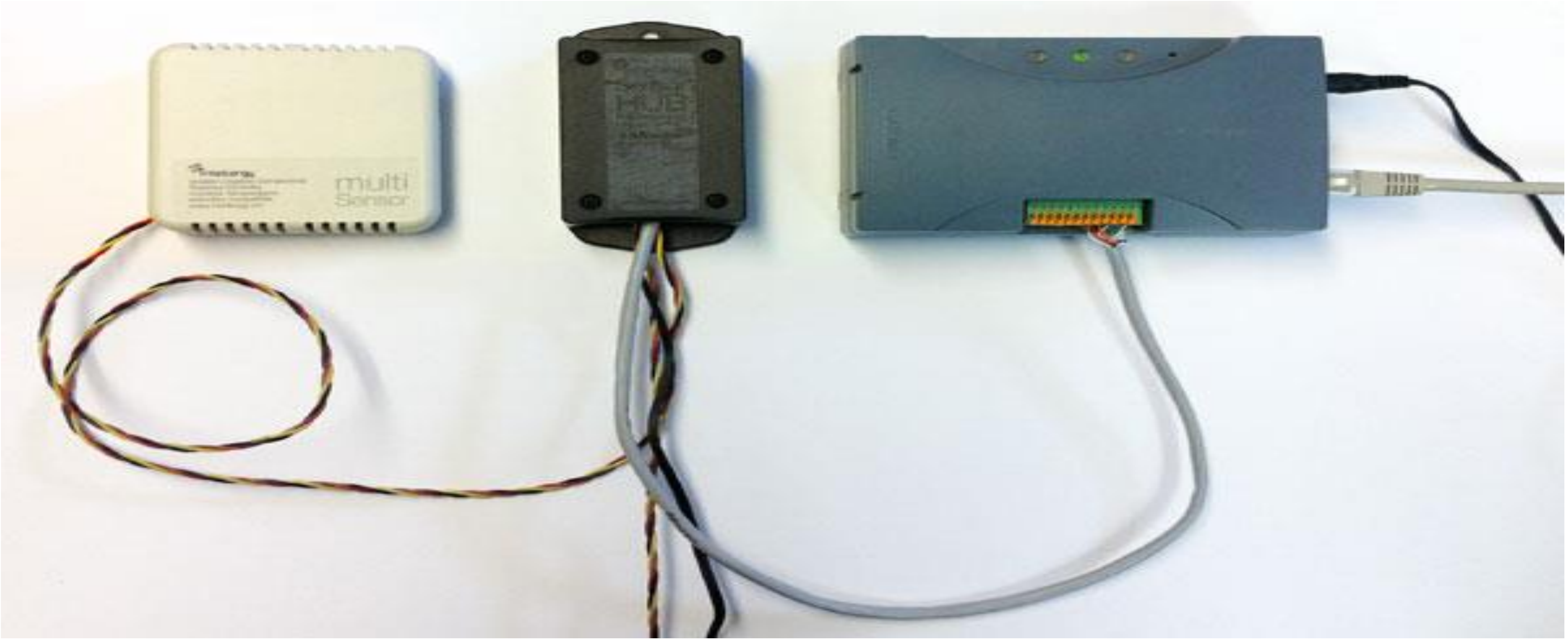
- The eMonitor Gateway requires an eMonitor to connect to the Internet and configure it properly.
- The sensors are connected to the PowerWise Sensor Hub, or the PowerWise inDAC, which connects in turn to the Gateway.
- The Gateway connects **wirelessly** or by **Ethernet** to the local network, and sends data to the Intellergy data servers, where it can be accessed in various ways.
- Add sensors and controls are added to the eMonitor during installation to analyze solar PV and hot water system health, water heater performance, A/C and heat pump efficiency, etc.

eMonitor Gateway cont.

eMonitor Gateway Installation

- A typical installation of an eMonitor Gateway with an Intellergy Sensor Hub and an Intellergy Multi Sensor is shown below.
- The Gateway comes configured for wireless connection to the local network. However, the Gateway shown is configured to use an Ethernet connection to the router. This is an option for installations in which the Gateway is too far from the router to connect wirelessly.

eMonitor Gateway Installation cont.



On the left is the [Intellergy Multi Sensor](). It's wired into the [Intellergy Sensor Hub](). Many sensors can be daisy-chained on a One-Wire Network, and connected to the Intellergy Sensor Hub. The Sensor Hub is in turn wired into the Gateway with standard cat 5 cable. This is shown for reference. Complete installation information and wiring diagrams comes with the equipment itself.

Circuit-Level Energy Monitoring

- The eMonitor provides an affordable solution for homeowners to monitor the energy use on every circuit of the home, giving them visibility of where energy is being used – and wasted – and the ability to take action.
- The eMonitor provides a unique combination of circuit- and appliance-level monitoring, continuous analytics and diagnostics, tailored recommendations, wide spectrum of safety, cost, and usage alerts, and easy-to-use web interface.

Circuit-Level Energy Monitoring cont.

Circuit-Level Energy Monitoring cont.

- The eMonitor's is the only energy monitor for monitoring all circuits in a home.
- The eMonitor provides detailed insight into a home’s energy usage, allowing for identifying when appliances aren't performing as they should.
- Learn where your cell phone chargers, coffee makers, and satellite receivers draw phantom power, costing money without the homeowner knowing it, and receive proactive alerts about your energy use.

eMonitor Features

- Home Energy Management
- Saving on your Energy Bill: End Phantom Power

Home Energy Management

- Proactive alerts tell you by email or text message if:
  - a circuit is on longer than it should be
  - the eMonitor can't connect to the internet
  - the estimate of an electric bill goes over a certain amount, set by the homeowner.

End Phantom Power Usage

- Phantom power users are also referred to as energy vampires.
- The eMonitor finds and pinpoints phantom/vampire loads.
- For the average homeowner that has up to 40 of these phantom devices, this feature will reduce energy usage by as much as $30-50/month.

inView Passive™ House Monitoring

- A powerful package of hardware and software designed specifically for monitoring Passive House buildings.
- Co-developed with Passive House Institute US (PHIUS) and Passive House and green building experts, inView Passive™ includes sensors, data acquisition and communication hardware, inServe™ data analytics and processing, and inView™ dashboard software.

inView Passive™ House Monitoring cont.

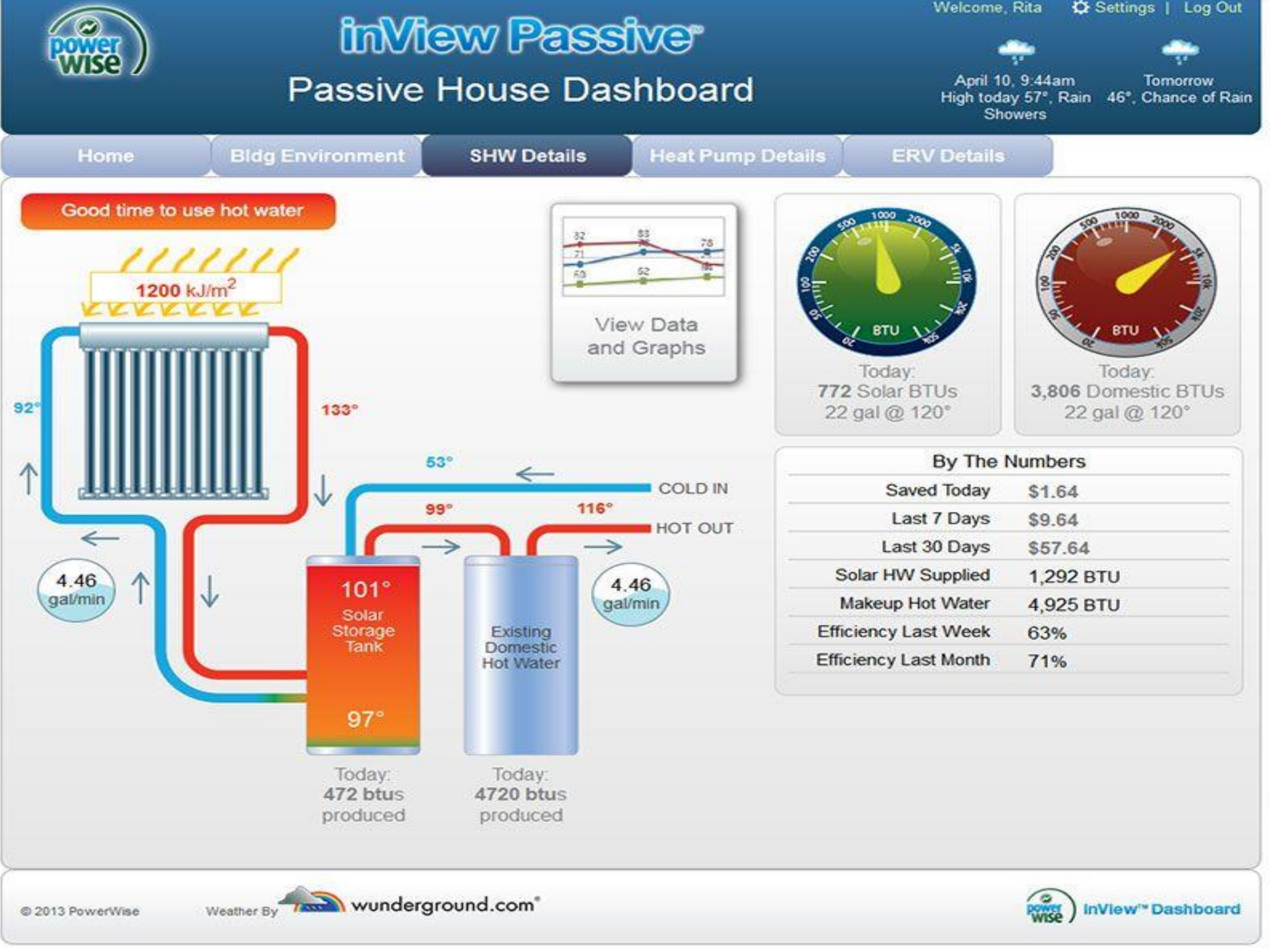
- Gain insight into performance, costs, and environmental conditions of entire buildings or individual HVAC and hot water systems.
- Visualize your solar hot water, ERV, HRV, and ground-source heat pumps with our detailed online dashboards.
- Know how these systems are running with real-time and historical readings. Plus, easily monitor circuit-level energy use, air quality, temperature, humidity, and more.

inView Basic Package

- eMonitor4-14 (2 mains + 12 circuits)
- inDAC™ (Data Acquisition Controller)
- 3 temperature sensors
- Relative humidity/temperature sensor
- VOC/relative humidity/temperature sensor
- Hardware enclosure
- inView Passive™ Passive House Dashboard
- Different hardware configurations are available to expand the monitoring capabilities.


power wise
inView Passive
Passive House Dashboard
Welcome, Rita
Settings | Log Out
April 10, 9:47am
High today 57°, Rain Showers
Tomorrow
48°, Chance of Snow
Humidity
100%
Temp
41°
38%
78°
0
500
1000
1500
2000
High
Medium
Low
AIR QUALITY
Watts
-5000
0
2500
5000
To Grid
Home
Last Mo
491 watts
Saved $25.55 this week
Green Power: 2061w
Grid Power: -1570w
5000
3750
1000
2500
0
Generated: 2061w
0w Wind
2061w Solar
Building Environment Details
Real-Time Electricity Details
Renewable Generation
112°
92°
Water is hot
74°
54°
42°
69°
1482 BTU
Saved
emonitor Login
Export My Data
N 18th St
Belfield Av
1700
Google
Map data ©2013 Google
Solar Hot Water Details
Heat Pump Details
ERV Details
My Location
© 2013 Intellergy, Inc.
Weather By
wunderground.com
power wise
InView™ Dashboard


powerwise
inView Passive
Passive House Dashboard
Welcome, Rita
Settings | Log Out
April 3, 1:24pm
High today 41°, Partly Cloudy
Tomorrow
52°, Partly Cloudy
Home
Bldg Environment
SHW Details
Heat Pump Details
ERV Details
Humidity
35%
Temp
38°
39°Avg
1 days
30%
68°
AIR QUALITY
High
Medium
Low
Day
Week
Month
Data | Min | Max | Avg
Outside Temp | 26° | 57° | 39°
Inside Temp | 67° | 70° | 68°
Inside Relative Humidity | 26% | 33% | 30%
Indoor Air Quality | 1268 | 1268 | 1268
Day
Week
Month
Year
temperature
voc
rh
temperature vs. voc
temperature (null)
voc (ppm)
04/02 2PM
04/02 5PM
04/02 8PM
04/02 11PM
04/03 2AM
04/03 5AM
04/03 8AM
04/03 11AM
temperature
voc
rh
LVL2-Hall (°F)
LVL2-BedRm (°F)
LVL3-BedRm (°F)
LVL1-Hall (°F)
LVL1-Living (°F)
LVL2-BedRm (°F)
LVL3-Mech R (°F)
LVL1-BedRm (°F)
LVL3-Office (°F)
LVL2-WashRm (°F)
LVL3 - Mech (ppm)


inView Passive
Passive House Dashboard
Welcome, Rita
Settings | Log Out
April 10, 9:44am
High today 57°, Rain Showers
Tomorrow
46°, Chance of Rain
Home
Bldg Environment
SHW Details
Heat Pump Details
ERV Details
Good time to use hot water
1200 kJ/m2
92°
133°
53°
COLD IN
99°
116°
HOT OUT
4.46 gal/min
101°
Solar Storage Tank
97°
Existing Domestic Hot Water
4.46 gal/min
Today: 472 btus produced
Today: 4720 btus produced
View Data and Graphs
BTU
Today: 772 Solar BTUs 22 gal @ 120°
BTU
Today: 3,806 Domestic BTUs 22 gal @ 120°
By The Numbers
Saved Today $1.64
Last 7 Days $9.64
Last 30 Days $57.64
Solar HW Supplied 1,292 BTU
Makeup Hot Water 4,925 BTU
Efficiency Last Week 63%
Efficiency Last Month 71%
© 2013 PowerWise
Weather By wunderground.com
InView Dashboard

Welcome, Rita | Settings | Log Out

inView Passive™

Passive House Dashboard

April 10, 9:46am
High today 57°, Rain Showers

Tomorrow
48°, Chance of Snow

Home | Bldg Environment | SHW Details | Heat Pump Details | ERV Details

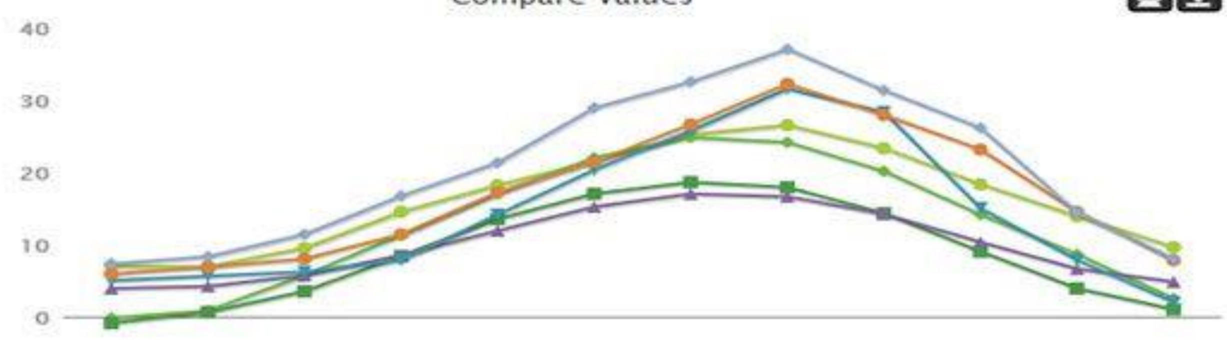
Data	Min	Max	Avg
Insolation	0w/m2	1180w/m2	630w/m2
Panel Temperature	-10°	147°	114°
Glycol Return	72°	118°	98°
Glycol Supply	70°	213°	162°
Glycol Flow	0	1.9gpm	1.4gpm
Cold Water In	49°	58°	54°
SHW Tank Bottom	62°	112°	98°
SHW Tank Top	72°	124°	118°
SHW to DHW	71°	122°	117°
DHW Out	112°	124°	118°
Water Flow	0	6.2gpm	2.4gpm

View Details

Day | Week | Month | Year

Export SHW Data

Temp
DHW BTU
Circ Pump
SHW
Irradiance



Temp
DHW BTU
Circ Pump
SHW
Irradiance

Welcome, Rita | Settings | Log Out

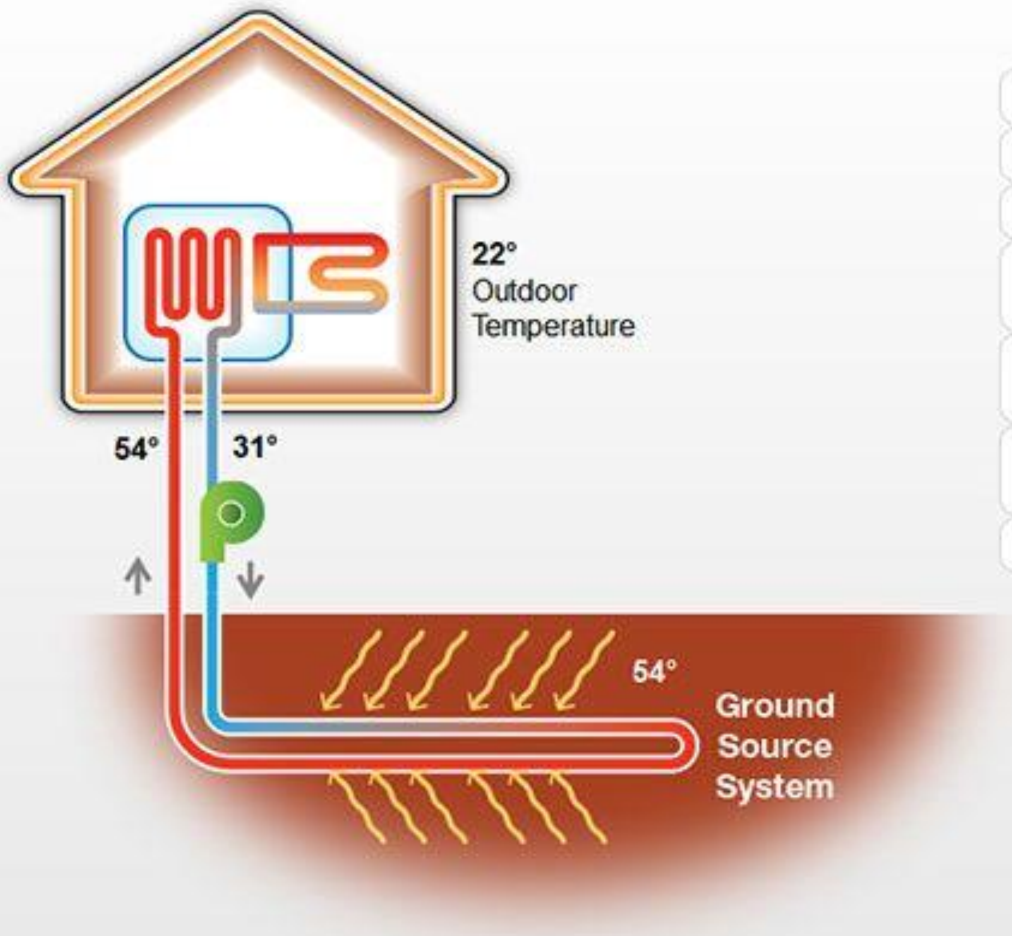
inView Passive™

Passive House Dashboard

April 10, 9:48am
High today 57°, Rain Showers

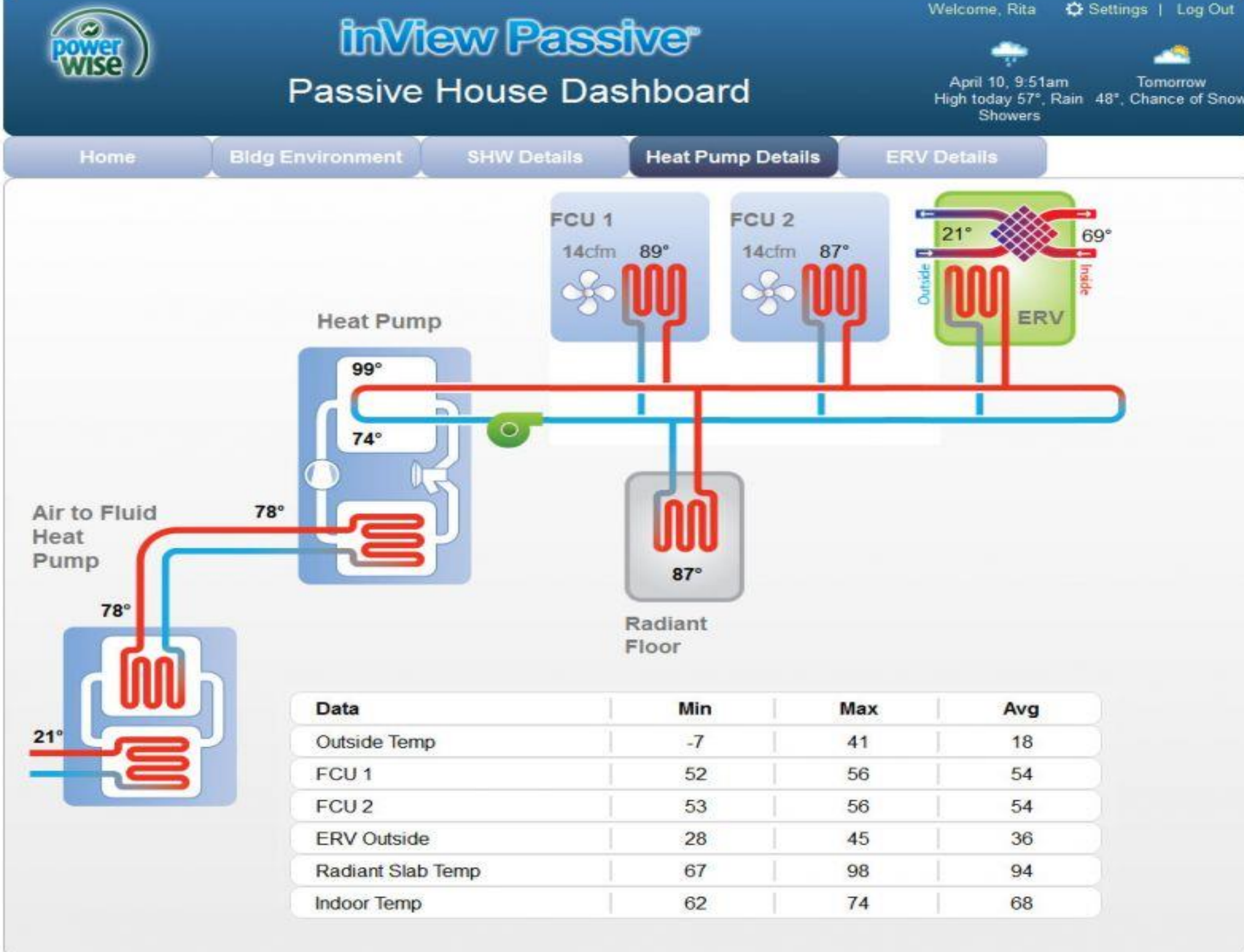
Tomorrow
48°, Chance of Snow

Home | Bldg Environment | SHW Details | Heat Pump Details | ERV Details



Data	Min	Max	Avg
Outside Temp	-7	41	18
Ground Temp	52	56	54
Ground Source Supply	53	56	54
Ground Source Return	28	45	36
Ground Loop Flow	0.4gpm	1.2gpm	0 0.8gpm
Indoor Temp	62	74	68

View Distribution Details



Data	Min	Max	Avg
Outside Temp	-7	41	18
FCU 1	52	56	54
FCU 2	53	56	54
ERV Outside	28	45	36
Radiant Slab Temp	67	98	94
Indoor Temp	62	74	68

power wise

inView Passive

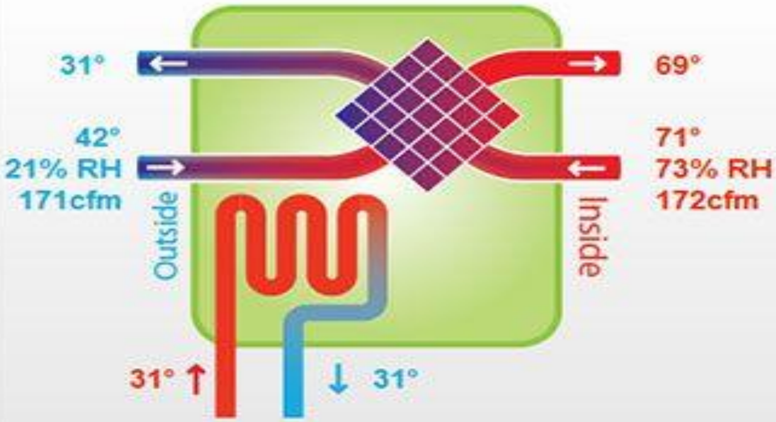
Passive House Dashboard

Welcome, Rita | Settings | Log Out

April 10, 9:55am
High today 57°, Rain Showers

Tomorrow
48°, Chance of Snow

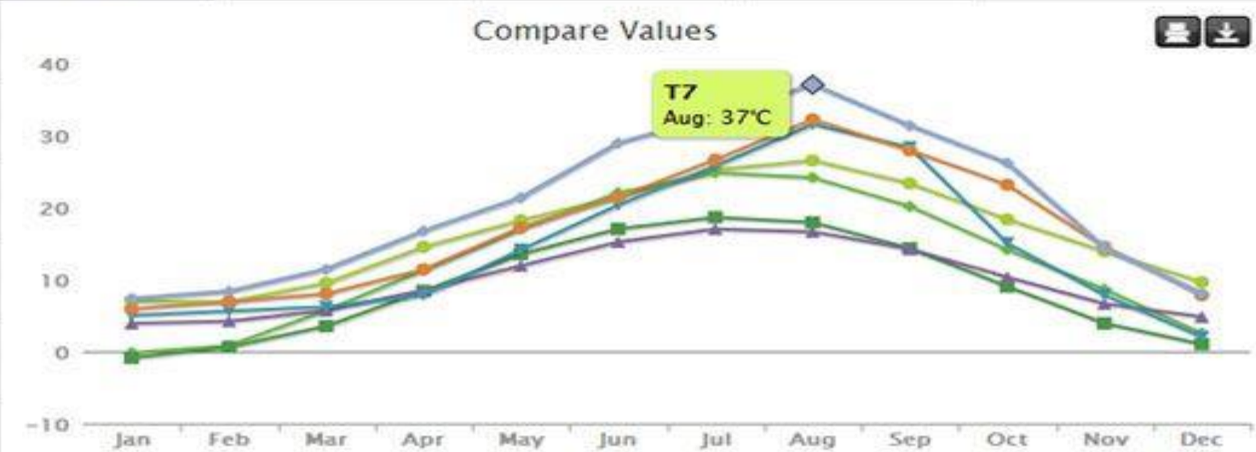
Home | Bldg Environment | SHW Details | Heat Pump Details | ERV Details



Data	Min	Max	Avg
Outside Temp	-7	41	22
Outside Relative Humidity	24%	95%	46%
Inside Temp	62	78	69
Inside Relative Humidity	42%	98%	56%
Supply Flow	21cfm	342cfm	173cfm
Return Flow	21cfm	340cfm	172cfm

Day | Week | Month | Year

Temp
DHW BTU
Circ Pump
SHW
Irradiance



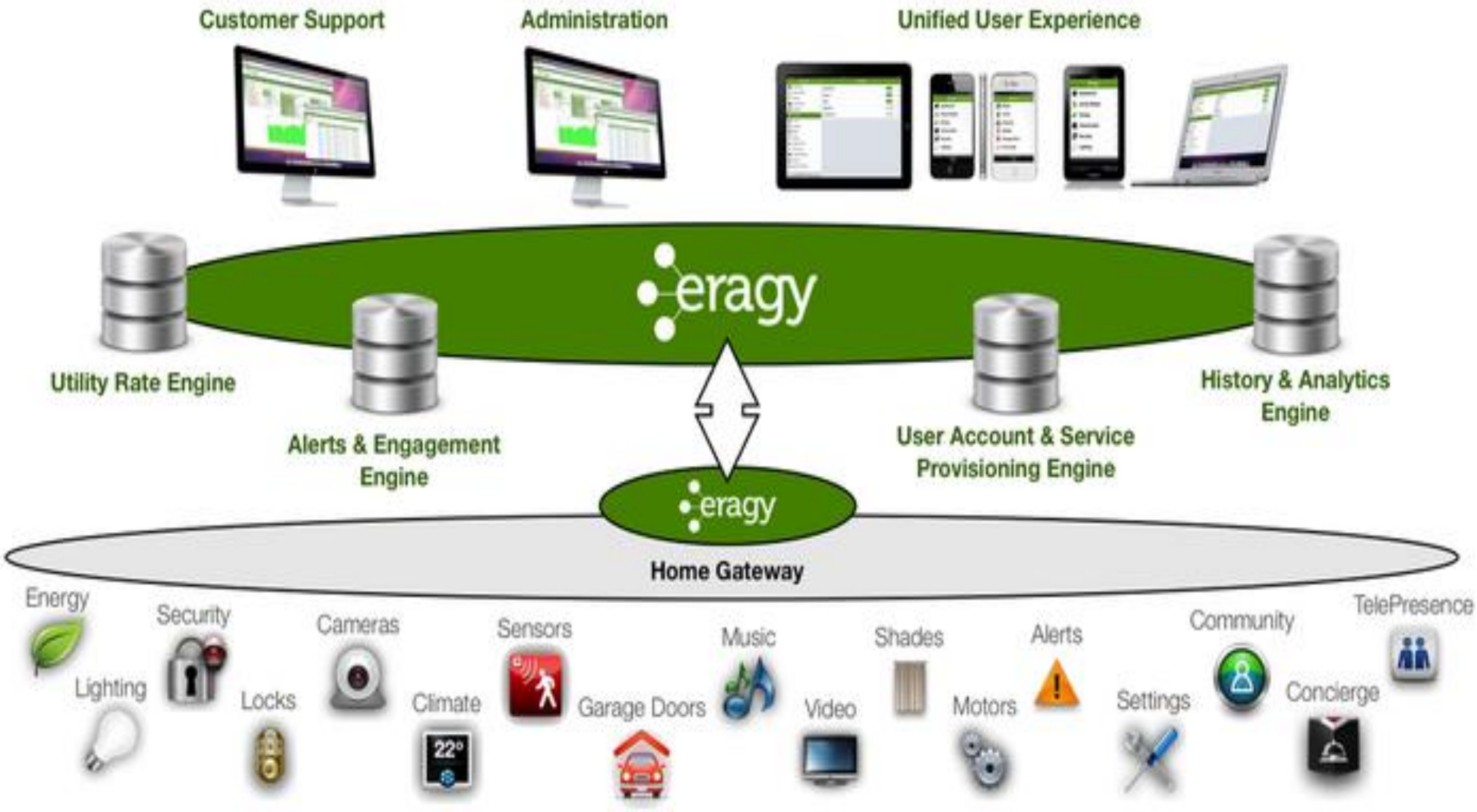
Temp
DHW BTU
Circ Pump
SHW
Irradiance

T1 | T2 | T3 | T4

Eragy Orbit & Control4

- Eragy Orbit and Control4 and their connected home platforms work in tandem with a home gateway which enables homeowners and businessmen to monitor and control their homes and businesses from anywhere using their cloud-based mobile platform.
- Orbit and Control4 users can monitor and control their energy, cameras, lighting, thermostats, door locks and more -- all from their mobile device!

Eragy & Control4 Solution



High Efficiency Windows & Doors

- AlpenWindows & Marvin Windows and Doors are leading the US industry in passive house design and architecture by developing state-of-the-art windows and glass doors.
- Quadruple glazing casement or picture windows will be utilized, possibly along with retractable awnings for southern Idaho's desert climate.
- When possible, emphasis will be on orienting homes on building lots to take advantage of southern exposure.

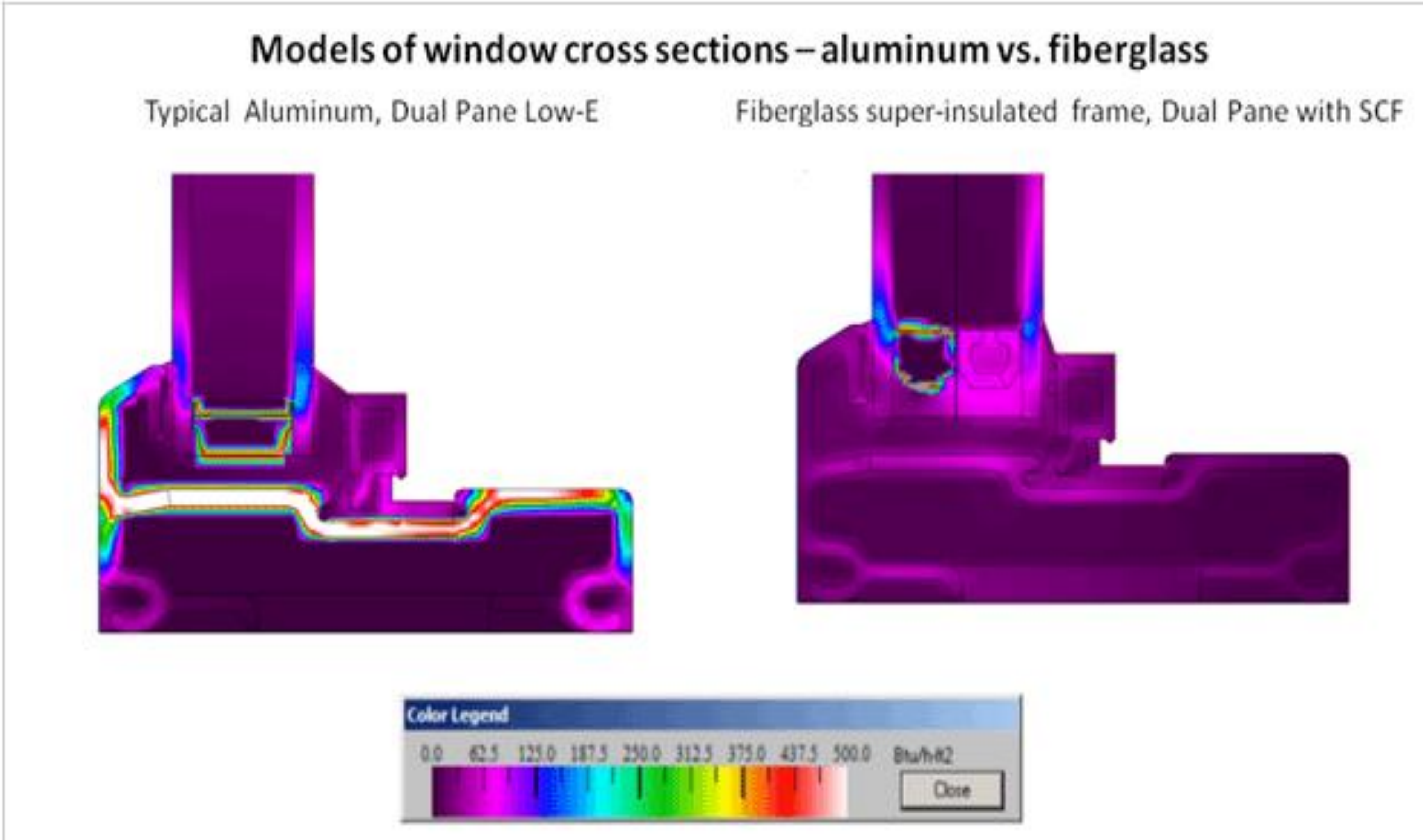
Understanding Full Frame High R-Value for Windows

- R-Value is a measure of thermal resistance used in the building industry.
- A high-R-value window has a greater resistance to heat flow and a higher insulating value than one with a low R-value.
- R-value is the inverse of the U-factor ($R = 1/U$) and is expressed in units of hr-sq ft-°F/Btu.

Aluminum vs. Fiberglass Frame

- The thermal image below shows the cross section of a standard dual-pane low-e aluminum framed window and the cross section of Alpen Windows' frame with two panes of glass and one layer of suspended film.
- The colors depicted show the amount of thermal energy (Btu/h-ft2) passing through the frame. Purple means virtually no thermal energy is transferring through.
- The more green, red, orange and yellow means the more thermal energy that is passing through with red representing the most energy being transferred.
- The white areas in the image at left indicate the highest level of heat transfer – this is like a highway for heat to leave the home.

Modeled via THERM 6.1 Simulation software, Lawrence Berkeley National Labs



Importance of Framing System

- The thermal image clearly reveals that in well made multi-paned, low-e windows, the main source of thermal energy transfer is through the framing system.
- Knowing the full frame R-value of a window is critical for ensuring a high quality, energy efficient window.

Five Factors That Affect Full Frame R-value of a Window

- The type of glazing material (e.g., glass, suspended film, treated glass)
- The number of air chambers created by multiple layers of suspended film or glass panes
- What type of gas, if any, is used to fill the air space(s)
- The thermal resistance of the frame and spacer materials
- The “tightness” of the window – how much air leaks through

Triple Pane vs. Suspended Film

- The transition from single pane glass to dual pane (with a single chamber) provided an improvement in window energy performance. In much the same way, the introduction of multiple-chamber glass packages – with two to three insulating chambers and multiple surfaces using lightweight, suspended film layers – allow for significant improvements and advantages over triple-pane windows.
- Triple-pane windows are often viewed as the best performing window on the market. This is a flawed concept; triple-pane windows do not automatically equate into the best thermal performance. Thermal performance of a window is dependent on the entire window system, not just the number of panes.

Problems with Triple-Pane Windows

- Triple-pane glass units are significantly heavier than Alpen Windows.
- The heavier glass units require stronger framing systems which can increase the overall cost of buildings.
- The extra weight can also impose strict size constraints, and may affect how much glass is used in the design of a building – impacting the overall aesthetics of a structure, as well as comfort, the amount of natural day-lighting in a building, and even energy efficiency performance.
- General functionality of triple-pane windows is also affected by their weight.
- Additional stress is placed on all operable mechanisms of a triple-pane window as well as the window’s hardware, wearing them out quicker.

Disadvantages of Triple Pane Windows

- Increased project costs (more labor, sturdier frames, stronger building design)
- Aesthetic and design limitations due to size constraints imposed on the glass and window units
- Extra weight caused by stress on the entire window frame, potentially creating gaps that will allow air, water and dust infiltration
- Amount of natural light in the overall design may be reduced
- Additional stress on operable portions of the window and window hardware
- Wider glass packages may not fit framing systems or window openings

Advantages of Suspended Film

- Suspended film (SF) is one of the most significant technologies critical to improving insulation and achieving higher performance across a broad spectrum of glazing characteristics – without any of the design and durability limitations typical of triple-pane glass systems.
- Internally mounted, suspended films work together to complement the benefits of low-e glass. Combining both film and glass-based coatings creates a lightweight, multi-chamber insulating glass unit that reflects heat and harmful UV radiation while maximizing light transmission, and provides superior insulating performance.
- One or more layers of suspended film in between two panes of glass are separated by low conductivity spacer systems to improve the insulating performance at the edge of the glass unit, providing high full-frame R-values. A variety of inert gases can also be used to fill the air spaces to further block heat transfer.

Benefits of Suspended Film glazing in AlpenWindows

- Directional tuning to enhance day-lighting while better controlling morning warmth and afternoon coolness.
- 99.5+% UV protection reduces interior fading and damage and contributes to healthy, more comfortable indoors.
- More architectural freedom to include more glass in the design than triple-pane windows.
- Better condensation control with more insulating chambers than triple-pane windows.

Triple Pane vs. Suspended Film Comparison Chart

Window	R_{pi}-Value	Avg. winter glass temp (F)	SHGC	Weight per ft.	UV blockage	Tuned solar control system
Alpen Windows	Up to R-9.1	65	.20-.60	3.4	99%	Yes
Triple Pane w/Low-E	Up to R-5	59	.27	5.1	94%	No

R-Value: the higher the number the better the insulating value
SHGC: the lower the number the more comfortable the window in the summer heat, while a high number can be used on certain elevations for passive winter-time heating.
STC Rating: the higher the number the better the sound abatement.
Weight per ft: important to keep weight low to minimize wear on operating hardware.
Tuned solar control: the ability to provide windows/gas with different R-value, SHGC, and visible light characteristics to maximize comfort and energy efficiency.

Selecting Full-Frame Windows for Thermal Efficiency

- Many windows available today can achieve a relatively high center-of-glass insulation performance number.
- However, many are poorly manufactured and are made of a material that is not an effective insulator so building owners will experience draftiness from increased condensation and air leakage.

AlpenWindows 925 Series

– Up to R-9.1 insulation
– 3x Energy Star® rating
– 99.5% UV Protection
– More than three times more efficient than Energy Star standards.
– Quadruple-pane glazing in foam-filled fiberglass frames maximize insulating power to create comfortable, efficient homes in even the most severe cold climates.
– Available in casement, picture windows, and awnings for passive house design.

Casement Window

Casement Exterior
(Sandstone color)

Casement Interior
(with Fir Veneer)

Casement Interior
(showing Screen)

HP (High Profile) Picture Window

(Exterior) Almond color

(Exterior) Dark Bronze Color

Awning Window

Exterior - White

Interior - Fir Veneer

AlpenWindows 925 Series

AplenWindows 925 Series Highlights

- Alpen Windows combine an advanced glass package with superior fiberglass framing systems to achieve high insulation performance across the full-frame — not just measured at the center of glass.
- “Tuned” to a home’s unique location and solar exposure: Their tuning expertise and glazing options will ensure the right amount of heat to warm or cool a home for thermal efficiency, maximum comfort, and reduced energy usage.
- Their 925 Series glass packages provide a remarkable inside glass surface temperature of 65°F or more on a cold winter day based on NFRC 100-2010 environmental conditions (0°F outside / 70°F inside / 15 mph wind).

AplenWindows 925 Series Highlights cont.

- Custom made to match your home’s distinctive architecture: Alpen Windows are available in multiple sizes, styles, shapes and colors and with optional stainable wood veneers. Alpen Windows are custom made to meet your home’s exact specifications and style at no extra cost.
- Traditional classic wood window aesthetic: Alpen Windows offer the beauty and look of classic wood windows. Alpen Windows fiberglass windows offers custom stainable interior wood veneers and classic lines and grid profiles that match the feel of wood windows but without the hassle, weight and maintenance.

AplenWindows 925 Series Highlights cont.

- High strength, low conductivity fiberglass frame: Fiberglass is considered the “greenest” material for window frames. Fiberglass offers durability, better thermal performance, and lower embodied energy than vinyl, aluminum, and wood framing materials.
- Clean, contemporary hardware: Alpen Windows hardware offers a unique, clean, contemporary design that does not obstruct views and reduces the tendency of the window to “walk” in buffeting wind conditions. The hardware finish is engineered to resist a wide range of corrosive materials.

AplenWindows 925
Series Highlights cont.

- Multi-seal weatherstripping design: Alpen Windows conforms to the rain screen principle with high quality air and water tight seals.
- Fiberglass insect screen: The screens are easily removable, non-glare, fiberglass. They will not rust, corrode, stain or impede visibility.

AplenWindows 925 Series Highlights cont.

- UV protection: Alpen Windows are engineered to block up to 99.5% of harmful UV rays. Their advanced glazing systems reduce fading and interior damage and contribute to a healthy indoor environment – all without obstructing natural lighting and visibility.
- Lifetime warranty: All Alpen Windows are covered by a limited lifetime warranty.
- Easy, safe cleaning: designed to tilt-in, lift-in or pivot-in, Alpen Windows allow for easily cleaning windows from the inside of your home safely and easily.

AlpenWindows 725 Series
Sliding Windows & Glass Doors

– Up to R-7.1 insulation exceeds Energy Star® standards

– 99.5% UV protection

– Reduced condensation

– Available in Casement, Picture Windows, and Awnings

Advantages of AlpenWindow Technology

- The cutting-edge fiberglass framing systems of Alpen HPP offer superior performance to conventional fenestration materials in a number of ways: durability, stability and efficiency, making it the optimum material for super-insulating windows and preserving overall performance for the life of a window.
- Extreme corrosion resistance: fiberglass is the only framing material that particularly resists environmental damage caused by corrosive salt air or high temperatures.

Advantages of AlpenWindow Technology cont.

- Superior insulator even in extreme environments: dimensional stability even in extreme thermal cycling (heat, cold humidity), Alpen Windows fiberglass frames offer the aesthetic of classic wood clad windows but with better insulation.
- High condensation resistance: the insulating nature of fiberglass prevents condensation and helps keep humidity within a proper range, this limits the growth of molds and mildew and helps keep your home’s interior air quality healthy.

Advantages of AlpenWindow Technology cont.

- Superior strength to weight ratios: Alpen Window’s fiberglass series are ideal for large window openings – they are 86% of the yield strength of aluminum and are pound-for-pound, stronger than aluminum.
- Practically maintenance free: the inherent strength and nature to distribute impact loads even in sub-zero temperatures, fiberglass frames will not suffer the pockmarked surface damage that is common to wood and aluminum windows, and because fiberglass takes paint easily with excellent adhesion, you can change the color of your windows any time you like.

Advantages of AlpenWindow Technology cont.

- Very low coefficient of thermal expansion and contraction: stresses on seals, caulks and joints are minimized, contributing to higher efficiency windows and tight seals that are resistant to air leakage and water penetration.
- High glass to frame ratio: the strength of our fiberglass frames means more of a viewing area because of the higher glass to frame ratio, compared to wood windows.

Passive Window Shades

- Marvin has designed shades specifically for their passive house certified windows (Ultimate Casement).
- They come with remote control motors that raise and lower blinds at night and mornings as well as during storms (and thus require a total of 5.5” larger window opening beyond the size of the window).
- In addition to blocking solar radiation during warm seasons, these shades provide additional insulation via dead air space for winter and summer months.

Marvin Passive Window Shade Exterior

Marvin Passive Window Shade Interior

Hammer & Hand Doors

- Passive wood entry doors made in the US lead the industry in energy efficiency.
- Provide an R_{pi}-14 via a 3.5” fir wood and EPS foam insulated door.
- Includes a 5 point locking system and comes with a custom door jam to insure air-tight seal and provide added security.

Flush View of Passive Wood Door

Hammer & Hand
Entry Door Production

Quality Design & Production

- Vacuum clamping bag used in lamination of Passive House door
- Door jamb of custom Passive House door features in-kerf weatherstripping.
- Five point interlocking hardware.

Groke Passive House Entry Doors

- Groke Doors range up to 94 mm (abt. 3 inches) thick, constructed of aluminum and dense foam insulation.
- Their highest energy efficiency door has achieved a U-factor of 0.13, e.g., and inverse R-factor of over 8.
- These doors come with an aluminum and foam frame, providing increased security and virtually eliminating air leakage via 3-5 point locking systems.

Groke Door Construction

High Efficiency Appliances

- The Consortium of Energy Efficiency publishes a yearly list of the most efficient appliances (tier 3) for residential and business applications which substantially exceed federal standards.
- The top performing manufacturers will be invited to contribute and showcase their appliances in our model home (for demonstration of passive house technology).

Energy Star Appliances

- Appliances account for nearly 20% of the average household’s energy use.
- A comprehensive package of ENERGY STAR qualified appliances can save up to $80 a year in energy costs compared to standard appliances.

Beautiful Concrete Floor Designs

- Can be developed for a variety of colors and designs for concrete floors.
- Providing unmatched quality and craftsmanship similar in decorative looks to polished marble or granite.
- Can be designed and applied to fit any homeowner budget.
- Ideal for use with radiant heating and cooling via Quad-Deck technology.




Concrete Dying & Polishing

- Conducted after the concrete is poured and cured, and bearing walls are in place.
- An extremely flat surface is required for best finish.
- Sub-contractor fees run from $4-5/sf. (primarily labor)

Concrete Countertops

- Relatively low-cost substitute vs. corian and granite while much higher quality than laminate.
- Materials are low-cost.
- Concrete coloring and design allow for very attractive floors and countertops and very competitive pricing.
- Sinks can be constructed with concrete and integrated with kitchen and bathroom countertops.

Drop In & Undermount Sinks

- Both are available for use with pour in place concrete countertops.

Pour in Place with PVC Edging

- There are significant economic advantages for pouring in place using PVC edging forms that also serve as guides for screeting to provide a level and flat surface.
- This eliminates grinding, moving, and transporting heavy concrete countertops.
- The following photos of pour in place concrete countertops use a variety of edging form styles, coloring, and dyes from Z Counterform Concrete Countertop Solutions .


BE NICE...OR GO AWAY


Checker/Chess Board Dyed into Concrete Countertop

Residential Energy Tax Credits

- 30% for geothermal heat pump systems
- 30% for solar power systems
- 30% for wind power systems

Energy Efficiency Mortgages

- More and more lenders provide so-called "Energy Efficient Mortgages" (EEM).
- These mortgages recognize the fact that highly energy efficient homes cost less to operate.
- This in effect increases a borrower's income - money in your pocket or to qualify for higher mortgage amounts/shorter terms.

How an Energy Efficient Home more than Pays for Itself

- Borrower finances 100% of energy improvements - 6.0% 30-year mortgage	Standard Mortgage	EEM
Energy Improvement Costs	-	$6,000
Appraisal Value	$200,000	$206,000
Down Payment	$20,000	$20,000
Mortgage Amount	$180,000	$186,000
P & I	$1,079	$1,115
Monthly Energy Savings	-	**-$80**
Total Monthly Payments	**$1,079**	**$1,035**

Passive House Savings

- This means that after paying for the additional cost of Quad-Lock ICF there is an additional savings of $44/month, $528/year, and more with rising energy costs...
- Savings would be even greater with integration of geothermal heat pump, radiant heating, cooling, hot water heating systems, efficient windows and doors, and high efficient appliances via passive house design

Prequalifying via EEM Lender

Steps:

- Pre-qualify with an EEM Lender (see Dept. of Energy Listing)
- Evaluation of home's energy efficiency (e.g., inspection by a professional energy rater, see RESnet Rating Providers)

Builder Incentives

- A credit of $2,000 is available to home builders who build high-efficiency homes (including both site-built and manufactured homes).
- Qualifying homes must be designed so that heating and cooling energy used will be 50% less than a home that meets the standards of the 2006 International Energy Conservation.
- In addition, a $1,000 credit is available to manufactured home producers producing models that save 30% or that qualify for the federal Energy Star Homes program.
- **These credits are available for buildings or systems placed in service from January 1, 2006, through December 31, 2013 (**IRS Form 8908**).**

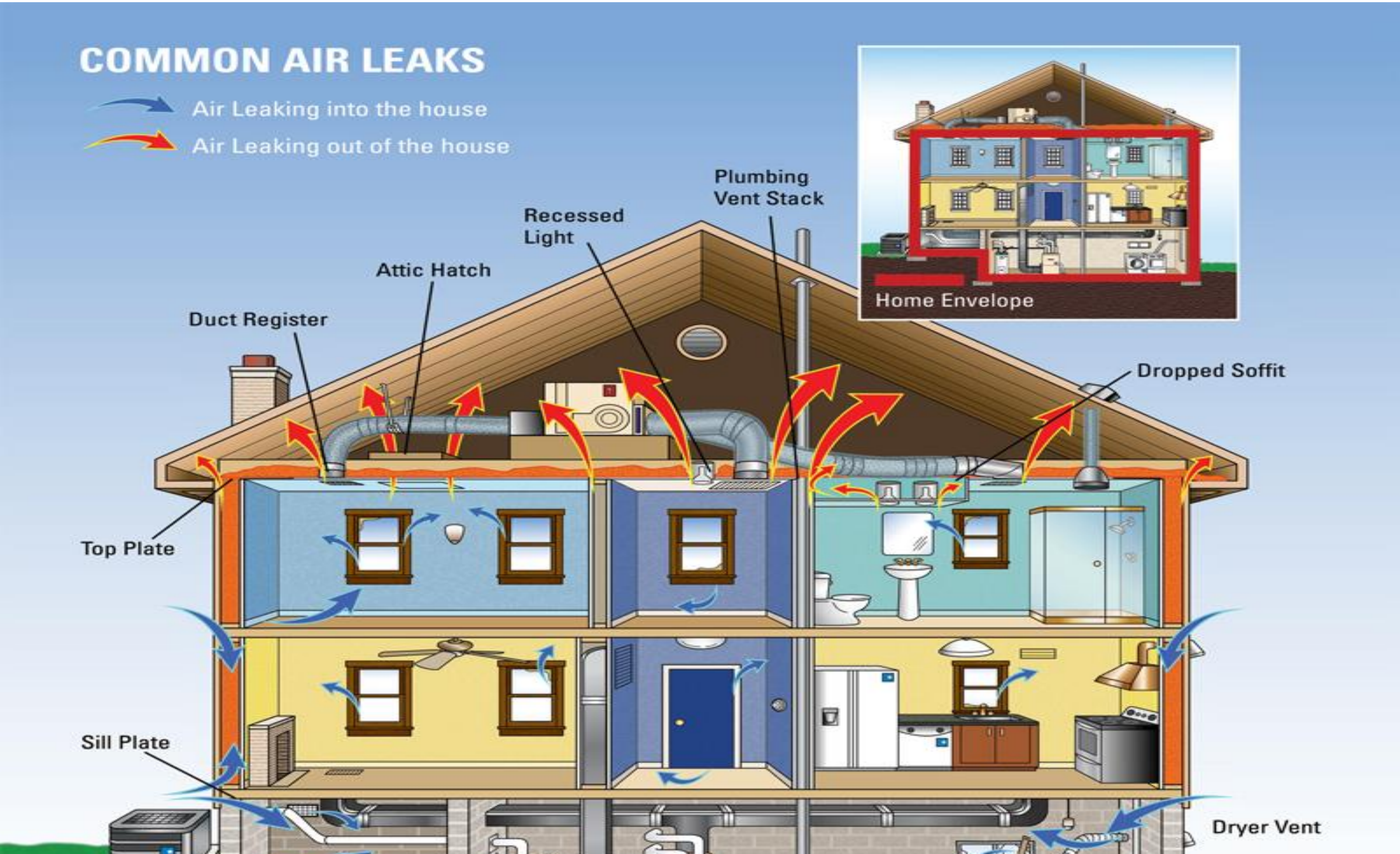
Idaho Home Sales

- Idaho property vales have increased by 30% over last year.
- New homes sales in Boise, ID have dramatically increased, many are selling before construction is complete.

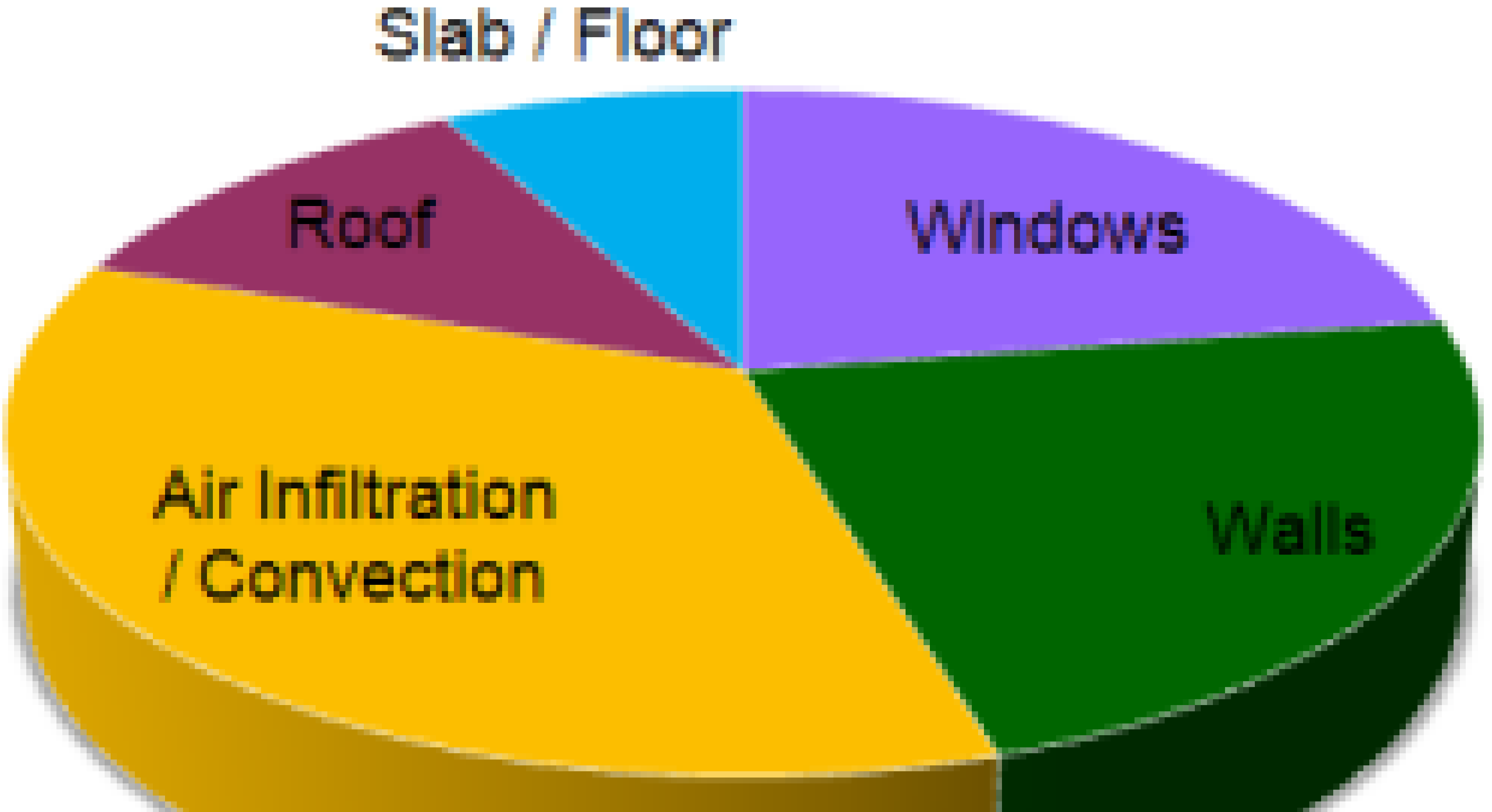
Passive House Model Home Design

- Roof overhangs, window size and placement, and overall home shape have a major impact on achieving net-zero homes.
- Focus will be on managing solar gain.
- A strategic portion of the roof will face south and west.
- Placement of porches, garages, trees, and nearby buildings will be included in strategic plans for passive house design.

Avoiding Air-Leakage



Sources of Energy Loss in a Wood Frame Building



ICF, Passive Windows & Entry Doors will Minimize Air-leakage

- ICFs will ensure airtight walls and ceilings.
- Passive windows and doors will be utilized.
- Kitchen and bathrooms will be provided with adequate ventilation while maintaining energy efficiency. Triple glazed windows with minimal air-leakage and well insulated or external doors in covered/protected entry ways will be utilized.
- Passive gain of incoming solar heat through strategically placed windows will recoup close to 40% of heat losses.

Ranch Style Floor Plan with Full Basement & Loft

- A full basement provides the most cost effective use of building materials and labor resources.
- When a sloped lot is utilized, a walk-out basement is ideal.
- Using Quad-Lock and Quad-Deck ICF technology also allows for efficient use of loft space as a relatively inexpensive 2nd story.
- This almost triples floor space for the average home or office building.

Vaulted Ceiling & Loft

- Vaulted ceilings will be constructed using Quad-Deck and milled/sized logs to reduce shoring and enhance beauty for the upstairs loft/bonus room and venting/utility allies along all four sides of the structure.
- Eaves will be extended 4-5’ beyond walls using a 4-5” cement slab insulated with 5” of 4’ x 8’ sheets of dense foam glued to the concrete roof.
- The foam will be covered with OMB, anchored to the cement roof, and covered with a roofing membrane.

Boise Lodge Logs

- Milled logs from Boise Lodge Logs will be utilized to provide accurate sizing and uniform circular block-outs for ICF.
- Logs are cured using a 6-8 week solar energy process to minimize cracking and warping.
- Logs will come pre-drilled for anchoring to Quad-lock walls to provide shoring during pouring of floors and roof ICF structures.

Why Use Ventilation?

- To provide enough fresh air to keep the occupants healthy
- To remove odors
- To dilute indoor pollutants
- To lower the indoor relative humidity

Air Circulation

- Air circulation in a building ensures that dampness is minimized so that mildew does not grow.
- This is especially important in an ICF house where the walls themselves are significantly more air-tight than in stick-frame construction (which is one of the reasons for lower energy costs).

Heat Exchanger

- Proper air circulation can be accomplished by installing a heat (HRV) or energy recovery ventilation (ERV) system in conjunction with radiant heating, cooling, and hot water.
- Such HRV systems utilize a heat exchanger to transfer heat from outbound air to inbound air using geothermal loops similar to ground to air heat pump systems.
- This allows for preheating air in the winter and cooling it in the summer.

Managing Humidity

- To prevent moisture damage to a house, lower humidity levels are always preferable to higher humidity levels.
- In other words, dry is always better than damp. However, some people begin to complain if the indoor relative humidity is too dry — say, 20% or below. (Of course, people have lived healthy lives for thousands of years in climates where the relative humidity is often below 20%, so it's not at all clear that low humidity levels are unhealthy.)

Managing Humidity cont.

- Ventilation can only reduce the indoor relative humidity if the outdoor air is dryer than the indoor air.
- Since cold air can’t hold as much moisture as warm air, ventilating a house helps lower the indoor relative humidity only when it’s cold outside (or on dry days during the spring and fall).
- In most parts of the U.S., ventilation during hot weather actually introduces *more* moisture into the house — that is, it tends to raise rather than lower the indoor relative humidity.

Mechanical Ventilation Systems

- A balanced ventilation system with an HRV or an ERV is the preferred ventilation system for a Passivhaus building.
- Although balanced ventilation systems are relatively expensive to install, they have the lowest operating cost of any ventilation option.
- The purpose of an HRV or an ERV is to deliver fresh air to a home's interior without losing or using more energy via a heat exchanger.
- Neither appliance is designed to provide makeup air for combustion appliances or kitchen exhaust fans.

Ventilation Strategy

- Use state-of-the-art mechanical ventilation system (HRV or ERV >90% efficient)
- Design duct runs to maximize efficiency of the ventilation system while sharing ducts (and possibly ground to air coils) with forced air cooling provided by the geothermal heat pump.
- Eliminate all dedicated local exhaust systems for bathrooms, kitchens and laundry rooms that are ducted directly outside.
- Eliminate all other dedicated appliance exhausts that are ducted directly outside.

Minimum Requirements for Passive House Ventilation

- Air to Air Heat Exchanger must have:
  - Minimum 75% efficient heat recovery
  - Less than 0.8 watt/cfm, and
  - Meet a minimum air filtration level of F7
- Strongly encouraged by Passive House to use products that have electronically commutated motors

Minimum 75% Efficiency

- A 75% efficient unit exchanges 75% of the heat from the indoor air with the cold air coming inside.
- The closer that figure is to 100%, the closer the fresh, incoming air will be to the existing indoor temperature.
- Efficient electrical consumption is basically referring to the type of motor used in the ventilator.
- European models typically are using the most efficient DC motors available, while unit made in the US will suck a bit more power.

High Efficiency ERVs

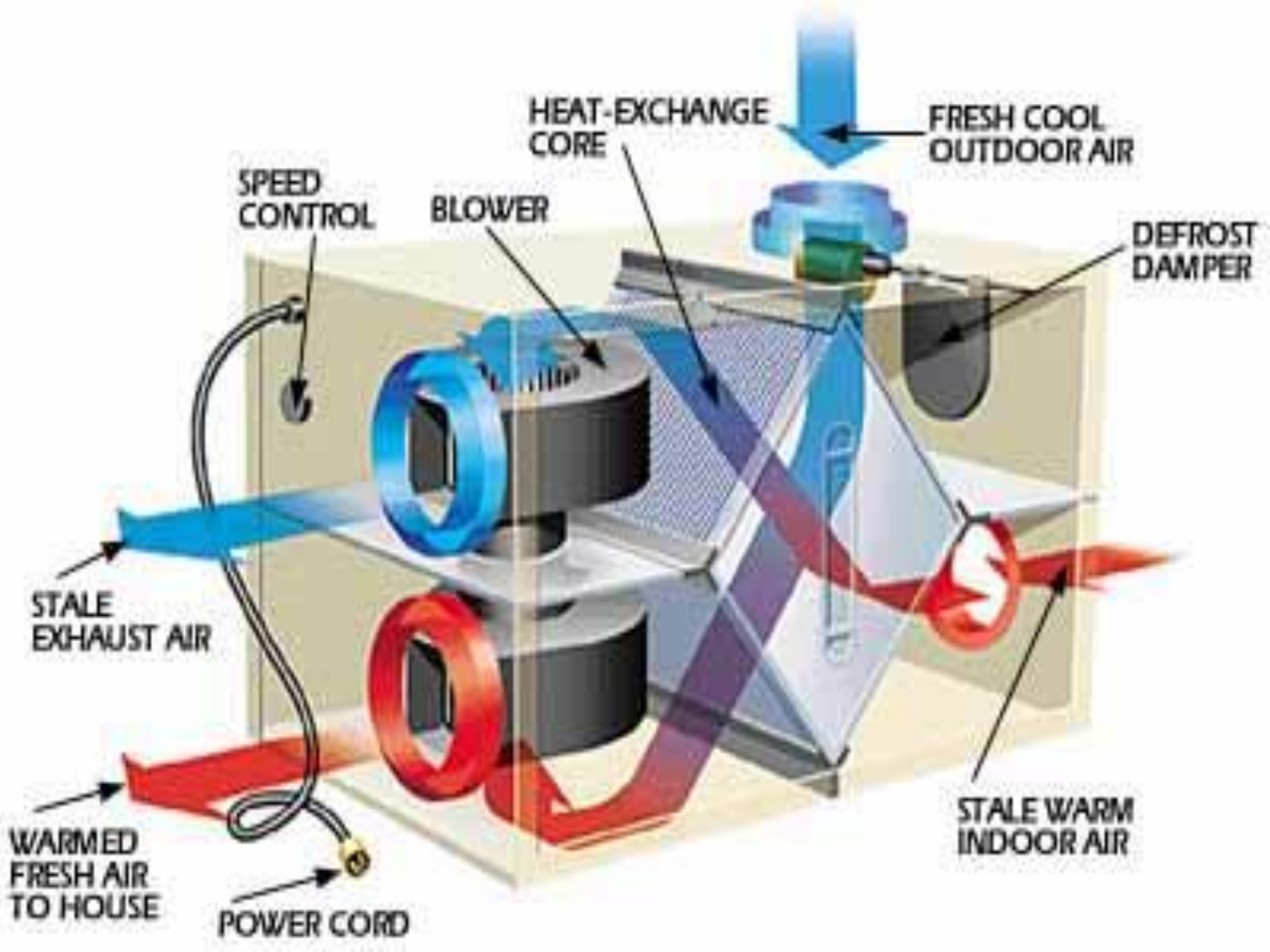
- For optimizing energy efficiency in a Passive House design, there are two primary choices:
  - UltimateAir RecoupAerator 200DX ERV (which draws 40 watts to deliver 70 cfm, or 1.75 cfm/watt)
    - The RecoupAerator is 200DX is 96% efficient
    - High efficiency electronically commutated motors
    - Capable of less than 0.8 Watt/CFM
    - MERV 12 Filtration
  - Venmar EKO 1.5 HRV (which draws 24 watts to deliver 49 cfm, or 2.04 cfm/watt).

Current PHPP inputs for the RecoupAerator® 200DX

- (Inputs currently under review)
- Heat Recovery Efficiency---------- 83%
- Efficiency Humidity Recovery--- 43%
- Electric Efficiency------------------ 0.72 watt/cfm

High Efficiency Mechanical Ventilation (ERV or HRV)

- Ventilation systems can be either a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV), both of which can substantially reduce energy loss.
- HRV’s exchange heat only while ERV’s exchange both heat and humidity.
- UltimateAir’s state-of-the-art RecoupAerator ERV works equally well in humid or dry climates and helps prevent moisture buildup, particularly in bathrooms and/or when using radiant cooling.


HEAT-EXCHANGE CORE
FRESH COOL OUTDOOR AIR
SPEED CONTROL
BLOWER
DEFROST DAMPER
STALE EXHAUST AIR
STALE WARM INDOOR AIR
WARMED FRESH AIR TO HOUSE
POWER CORD

HRV Technology

- Both the fresh air stream and the stale air stream flow through the HRV. The core of the appliance allows some of the heat from the warmer air stream (the stale air in winter, the fresh air in summer) to be transferred to the cooler air stream.
- In winter, in other words, the appliance “recovers” some of the heat that would have otherwise been exhausted. This heat transfer occurs without any mixing of the two air streams.

ERV Technology

- An ERV does everything that an HRV does. In addition, an ERV allows some of the moisture in the more humid air stream (usually the stale air in winter and the fresh air in summer) to be transferred to the air stream which is dryer.
- This transfer of moisture — called enthalpy transfer — occurs with very little mixing of the two air streams. (The cross contamination rate for one well-regarded ERV, the UltimateAir RecoupAerator, is 9.6%.)

UltimateAir® RecoupAerator 200DX

- The RecoupAerator 200DX is a whole-house air filter and ventilator that circulates fresh air into an average-sized home every two hours.
- It serves as both ventilation and filtration, capturing virtually all pollens and mold spores. This makes the RecoupAerator uniquely suited for asthmatics (MERV 12 filtration).
- It continuously exhausts stale air while capturing it’s temperature, conditioning and recycling it into the incoming fresh air.

RecoupAerator 200DX cont.

- Pre-filter: Washable aluminum mesh.
- Motor: General Electric ECM brushless motors. Electrical Rating: 120 VAC, 60 Hz., 6.0 amps. Mounting: Operates in vertical or horizontal position.
- May be suspended from joists or placed on floor or wall-mounted shelf. Connects to 6 inch ducts.
- The RecoupAerator® leads the air filtration industry with the highest energy recovery and highest filtration at the lowest amount of energy used.

EconoCool Feature

- **The Ultimate Air RecoupAerator** features an "EconoCool" feature that can be used during the summer to reduce cooling loads.
- Flick this switch on and the unit will recognize when the temp drops below 65° F and automatically shut off the energy recovery and begin swooshing cool night air directly into the house.
- In the summer time this feature can substantially reduce air conditioning loads when activated.
- Similar to capturing solar energy via windows in the winter, as much as 40% of energy lost during the warm season can be captured via cool nights in desert climates using this EconoCool feature.

Accomodating Multiple Floors

- Since the RecoupAerator is designed to move 200 CFM, it may be necessary to install more than one ERV to accommodate a basement, main floor and 2nd story.
- In this case, the geothermal heat pump could be integrated with the ERVs to provide forced air cooling for the main floor and 2nd story of the PHMH.

Passive House Duct Layout

- The ERV will remove (suck) stale air from the kitchen and bathrooms and deliver fresh air to bedrooms and living areas simultaneously.
- PHIUS (Passive House Institute US) consultants recommend categorizing suckers and blowers (technical postgreen terms) as follows:
  – Stale Air Exhausts (Suckers)
    - Bathrooms
    - Kitchen near Washer/Dryer
  – Fresh Air Inlets (Blowers)
    - Bedrooms
    - Living Room

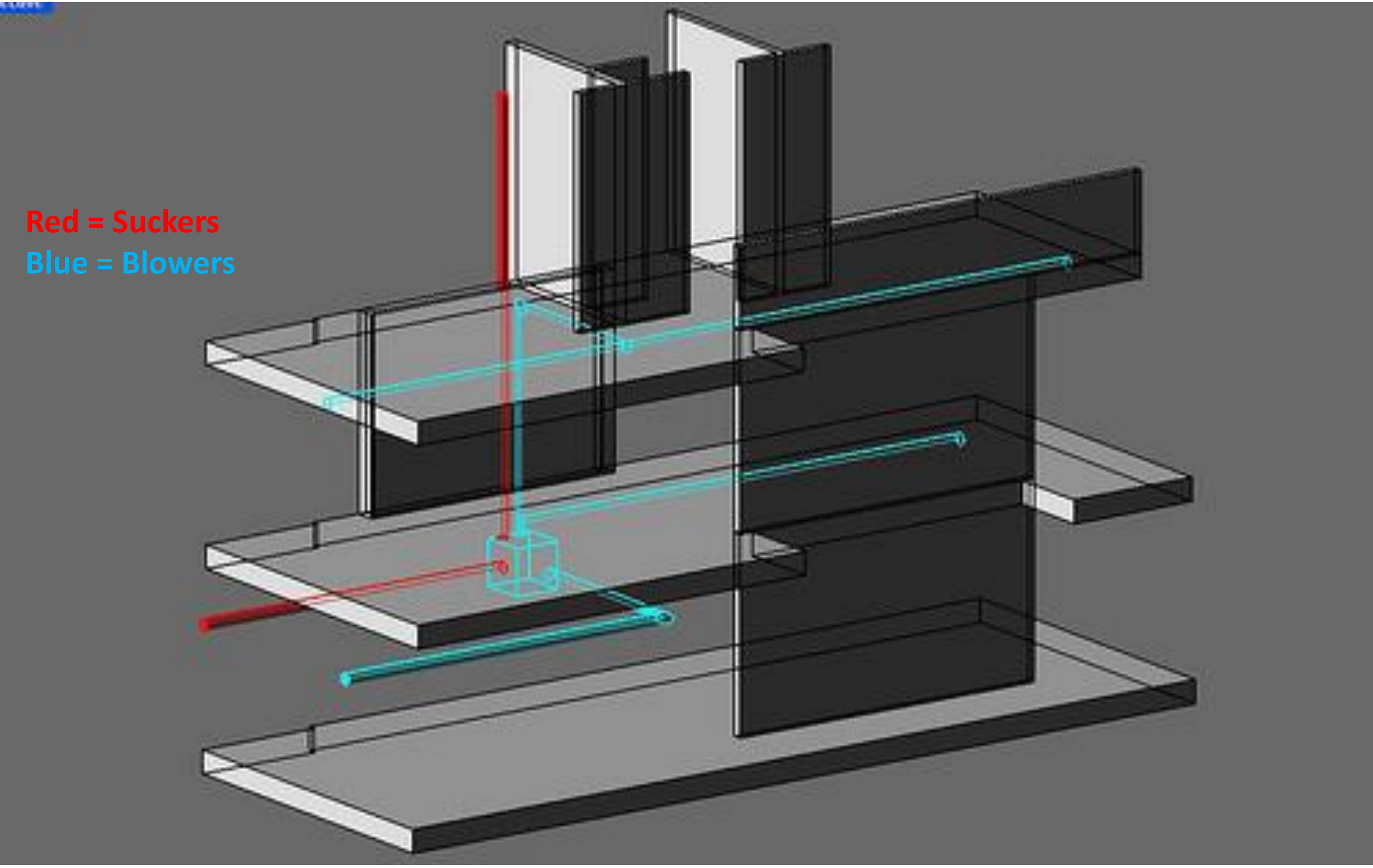
Duct Layout Design

- Locate the ERV at a central location of the structure to minimize length of duct runs and keep air flow rate less than 10 ft/s.
- Minimize 90° angles and have straight runs as much as possible. Basically a 90° turn is equivalent in resistance to airflow as 25′ of straight duct and a 90° register termination can add as much as 80′ to calculcations.
- Recommendations of both PHIUS and the manufacturer of the UltimateAir® ERV are as follows:
  - Keep it SHORT
  - Keep it STRAIGHT
  - Keep it SMOOTH

PHMH Strategic Floor Plan

- The floor plan of the PHMH will be developed to optimize duct layout:
  - Bathrooms and laundry room will be located in the same vicinity in order to share ducts.
  - Bathrooms on different floors will be located directly above and below each other.
  - Kitchens on different floors will also be located directly above each other.
  - The same goes for additional laundry rooms.

3D Duct Layout



PHMH Duct/Utility Access

- Quad-Lock ICF will extend 2' above the floor of the 2nd story. There will be a utility access for a 4/12 pitched roof measuring about 4' high x 18" wide on the 2nd story of the PHMH, extending around the entire perimeter of the home.
- The blower ducts and exhaust ducts as well as forced air (for air conditioning of the main floor and bonus room) will service the main floor as well as the 2nd story through block-outs cut into the Quad-Deck ICF floor/ceiling which will provide strategic radiant heating and cooling to the basement, bathrooms, laundry room, and possibly the kitchen.

Optimizing ERV System Performance

- We will use smooth, hard duct and avoid flexible duct as much as possible.
- We will insulate the two lengths of duct running between the exterior and the ERV. This will prevent condensation from forming on these ducts.
- If noise is a concern, we will add one 3′ section of insulated flex duct to the supply side of the ERV. It will be installed as straight as possible and it will act as a silencer without the need to buy an expensive silencing duct section.

Eliminate Dedicated Local Exhaust

- Passive ventilation strategies require increasing the amount of intakes/exhausts inside and eliminating the local exhausts in bathrooms and kitchens.
- PHIUS highly recommends doing away with any local exhaust that is basically removing conditioned air directly out of the homes and replacing it with outdoor air (due to air-leakage).
- Eliminating local exhausts also reduces exterior penetrations through the home by at least two sources (more for multiple bathrooms).
- To compensate for the lack of dedicated local exhausts, intake vents will be installed in the bathrooms and kitchens.

ERV Boost Switch

- An ERV boost switch tied to the light switch will be installed in each of the bathrooms so that occupants can boost the ERV fan to max setting (around 200 cfm for UltimateAir) while they are in use.
- Basically when you turn on your bath light, the ERV will automatically boost to high. When you leave the bath and turn off the light, the ERV will remain on boost for another 10-20 minutes to fully clear out remaining fumes.

Eliminate Exhausts for All Appliances

- This is less of a ventilation system design aspect and more of a whole house envelope and mechanical design strategy.
- By using the geothermal heat pump for hot water and a condensing dryer that does not require venting, we will eliminate all appliance ducting to the outside of the home.

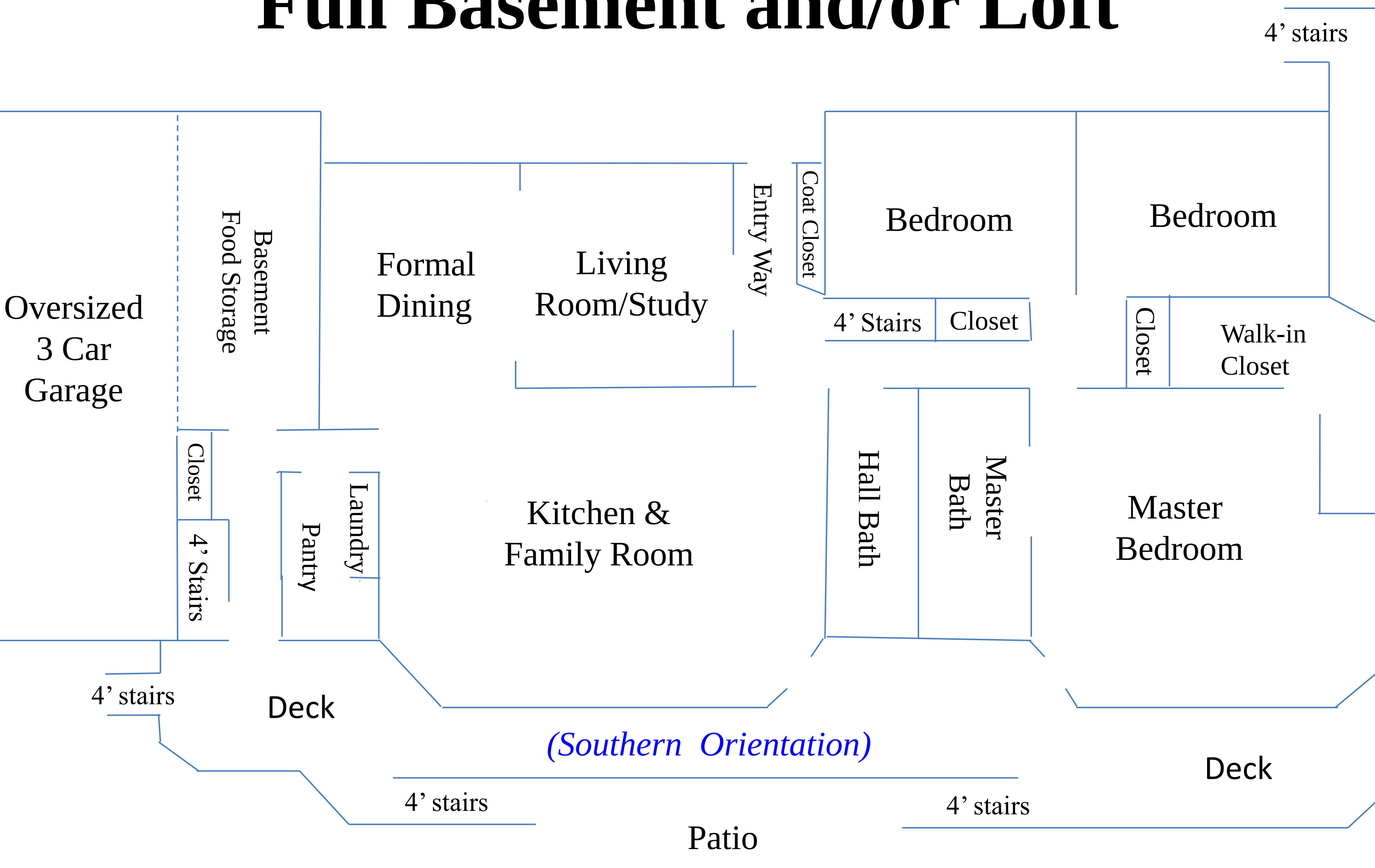
Envelope Pressure Testing & PHIUS Certification

- Will be conducted by Jerry Peterson, Mechanical Plan Review / Inspector – City of Meridian and HVAC / Residential Energy Program Manager - Idaho Division of Building Safety.
- Jerry works with Idaho contractors to develop and/or modify the existing IECC 2012 and later versions for adoption by the State legislature.
- Jerry is a nationally accredited HERS Rater (RESNET, home auditor.

Heat Pump, ERV & Radiant System Control

- Teckmar's tN2 406 House heat pump control and teckmarNet Thermostat 557 zoning may be used for the radiant heating, cooling, hot water, and coil backup system integrated with the ERV.
- The teckmar controller comes with a dew point reset and humidity regulator for using radiant cooling in conjunction with a hot/cold coil that will be integrated with the ERV.
- Due to the 200-300 CFM air flow limitation of the ERV, two ERV systems may eventually be employed to accommodate a basement, main floor and 2nd story.

PHMH Floor Plan
Full Basement and/or Loft



Rectangular Shape & Solar Orientation

- Allows for maximizing southern exposure and limiting northern exposure for passive solar homes built in the northern hemisphere.
- The rectangular shape also limits the size of the envelope which enhances energy efficiency.
- The majority of the windows for the PHMH will be placed on the southern side of the structure and treated to maximize solar gain.

Front Facing Garage

- The garage could be placed where the bedrooms are and then move the bedrooms upstairs to the 2nd story/loft over the garage.
- This would allow for reducing the length of the structure for accommodating smaller lots.
- A full basement could also be added via ICF technology and will possibly be showcased at the PHMH project.

Envelope Size

- The total square footage of living space for the above floor plan can be modified simply by proportionately reducing dimensions, from 1700-3200 sf. on the main floor.
- Full basements, insulated food storage, and lofts/2nd stories can be added to this design, providing additional bedrooms, bathrooms, family room, a home theatre, home office, or basement living quarters for in-laws, etc.
- The great room is optional.

Hayden Homes

- Very small lots in South Hill Subdivision
- Homes ranging from $77/sf to $103/sf:
  - **Parkland** - 1889 sf plus 365 sf optional bonus room, 3-4 bedrooms, 2.5 baths, 2-3 car garage - $195,000
  - **Waterville** - 2 story – 3195 sf, 4-6 bedrooms, 2.5-34.5 baths, 3 car garage - $245,000

Target Home Price - $75-100/sf in the Greater Boise Area

- Need to work with developer or establish own development to keep lot prices down and energy efficient homes competitive via EEM and tax credits.
- Medium price of homes available on 0.33 to 0.5 acre lots should be in the $250,000-350,000 range
  - 2,000-4000 sf with finished basement or 2nd story loft
  - 3-6 bedrooms, 2 family rooms, food storage, home office and/or home theatre
  - 2.5-4 baths
  - 2-3 car oversized garage

Reducing Material & Labor Costs

- Training in ICF construction, decorative concrete flooring, and concrete countertops will be conducted during the building of the PHMH.
- This will allow experienced ICF and decorative concrete crews to substantially reduce labor costs.
- Labor intensive sheetrock, taping, mudding, sanding, texturing and painting will be replaced with attractive ceiling decking and paneling using pre-treated pine or fir tongue and groove 1x6 or 1x8 products.

Industry Partners, Training & Referrals

- Industry partners will contribute materials and local contractors and subcontractors will contribute labor for building of the PHMH.
- In exchange for contributing labor, contractors and subcontractors will receive free training on materials, equipment, and techniques during the building of the PHMH.
- Contractors and subcontractors will be provided with contract work resulting from showcasing the PHMH. Once they become certified in ICF and other products/equipment, they will also receive referrals from product manufacturers.

Geothermal Heat Pump System

- Reducing the energy load by 90% may allow for using as little as a 2.5 ton variable capacity geothermal heat pump for over 4,000 sf.
- The labor intensive process of excavation and burying field loops will be minimized by laying horizontal loops around footings with monitoring and hydration systems in order to keep the groundwater source fully charged.
- The field loops and geothermal heat pump system will be integrated with radiant cooling, heating, hot water, and ERVs.

Monitoring Heat Capacity & Hydration Systems

- Dry soil has a heat capacity of about 0.20 BTU/lb./°F of temperature change—only one-fifth the heat capacity of water.
- Moist soils have better heat capacities of about 0.23–0.25 BTU/lb./°F.
- Hence, accurate monitoring of heat capacity and routine use of hydration systems can increase efficiency of field loops and geothermal heat pump systems by up to five fold.

Adding Value via Reduction of Energy Expenses

- Tax credits, the savings in monthly energy costs, and sweat equity will allow for homeowners to upgrade energy efficiency, e.g., passive windows and doors and the purchasing of more home for new construction.
- Additional upgrades could include:
  - photovoltaic panels for achieving net-zero homes
  - smart home technology including home security and home theatre
  - energy efficient appliances

Developing Net Zero Community

- Brooklyn NY and Issaquah WA (http://www.z-home.org/) have both successfully developed Passive House and Net Zero communities.
- Both of these communities have sold out.
- In order to insure that we are competitive and successful with our PHMH, we will find investors who are willing to develop such a community in Boise, ID.

zHome Condos Sold Out

- zHome is a revolutionary, 10-unit townhome development that uses smart design and cutting edge technologies to radically reduce its environmental impacts.
- zHome will prove that homes that use zero net energy and 60% less water, emit net zero carbon emissions, have clean indoor air and use only low-toxicity materials are possible and scalable to mainstream home production.

Cost is only 10-15% more than building to current codes

- According to Katrin Klingenberg, executive director of the Passive House Institute U.S. (PHIUS), her office receives at least one request each week from a developer seeking Passive House precertification. And the projects aren't only single-family homes; affordable housing, commercial and school projects also are in the works.
- "The growth since we began certifying Passive Houses in the U.S. has been exponential," Klingenberg said. "The beauty of the Passive House method is the simplicity of the system. As you eliminate the mechanical systems, the cost is only 10-15% more than building to current codes."